APPENDIX F

Other Test Method 30:
Method to Quantify Particulate Matter Emissions from Windblown Dust

Other Test Method – 30: Method to Quantify Particulate Matter Emissions from Windblown Dust

This method is designed to quantify particulate matter (PM) emissions from open areas susceptible to wind erosion where saltation flux can be measured. This method was submitted by the Great Basin Unified Air Pollution Control District (GBUAPCD) to EPA's Office of Air Quality, Planning and Standards – Air Quality Assessment Division – Measurement Technology Group (MTG) for inclusion into the Other Test Method (OTM) category on EPA's Emission Monitoring Center (EMC) website at http://www.epa.gov/ttn/emc/tmethods.html#CatC/. The posting of a test method on the OTM portion of the EMC is neither an endorsement by EPA regarding the validity of the test method nor a regulatory approval of the test method. The purpose of the OTM portion of the EMC is to promote discussion of developing emission measurement methodologies and to provide regulatory agencies, the regulated community, and the public at large with potentially helpful tools.

Other Test Methods are test methods which have not yet been subject to the Federal rulemaking process. Each of these methods, as well as the available technical documentation supporting them, have been reviewed by the Emission Measurement Center staff and have been found to be potentially useful to the emission measurement community. The types of technical information reviewed include field and laboratory validation studies; results of collaborative testing; articles from peer-reviewed journals; peer-review comments; and quality assurance (QA) and quality control (QC) procedures in the method itself. A table summarizing the available technical information for each method can be found at the link below. The EPA strongly encourages the submission of additional supporting field and laboratory data as well as comments in regard to these methods.

These methods may be considered for use in Federally enforceable State and local programs (e.g., Title V permits, State Implementation Plans (SIP)) provided they are subject to an EPA Regional SIP approval process or permit veto opportunity and public notice with the opportunity for comment. The methods may also be considered to be candidates to be alternative methods to meet Federal requirements under 40 CFR Parts 60, 61, and 63. However, they must be approved as alternatives under 60.8, 61.13, or 63.7(f) before a source may use them for this purpose. Consideration of a method's applicability for a particular purpose should be based on the stated applicability as well as the supporting technical information outlined in the table. The methods are available for application without EPA oversight for other non-EPA program uses including state permitting programs and scientific and engineering applications.

As many of these methods are submitted by parties outside the Agency, the EPA staff may not necessarily be the technical experts on these methods. Therefore, technical support from EPA for these methods is limited, but the table contains contact information for the developers so that you may contact them directly. Also, be aware that these methods are subject to change based on the review of additional validation studies or on public comment as a part of adoption as a Federal test method, the Title V permitting process, or inclusion in a SIP.

Method Revision History

Revision 1 – 3/22/2012
Revision 2 – 6/20/2012 – Received comments from the Los Angeles Department of Water and Power (LADWP); after review of these comments and additional supporting information, OTM -30 has been revised to include the LADWP comments (Appendix E), a GBUAPCD response to these comments (Appendix F), and an Expert Panel Report on the use of the Dust ID Model used in OTM-30 (Appendix G). **EMC advises all potential users to review the method and all appendices before application of this method.**

Method to Quantify Particulate Matter Emissions from Windblown Dust

1.0 Scope and Application

1.1. *Introduction.* The windblown dust emissions test method is designed to quantify particulate matter (PM) emissions from open areas susceptible to wind erosion. The method relies on comparing saltation flux to the difference in upwind and downwind ambient PM concentrations to quantify PM emissions. Saltation flux is a measurement of the mass of windblown sand and sand-sized particles that pass horizontally through a vertical plane. Saltation flux is measured in units of mass/area as opposed to PM concentration which has units of mass/volume. Experimental evidence has shown that the ratio of saltation flux to PM emissions can be characterized for a given surface for a given time. This ratio can be used with saltation flux measurements and dispersion modeling to calculate PM emissions by comparing model predictions to measured ambient PM concentrations. [1,2]

1.2. *Applicability.* This method can be applied to any open surface area susceptible to wind erosion where saltation flux can be measured. Depending on the type of ambient PM monitoring used, PM emissions can be quantified as particulate matter less than 2.5 microns ($PM_{2.5}$), less than 10 microns (PM_{10}), or the coarse fraction of PM_{10} ($PM_{10-2.5}$).

1.3. *Data Quality Objectives (DQOs).* Data quality objectives define the appropriate data to collect, the conditions under which to collect the data, and the criteria for data acceptability for each project. Although DQOs are project specific, some general DQOs apply to all projects conducted to quantify the particulate matter contained in windblown dust. These DQOs include population uncertainties and measurement uncertainties. Population uncertainties include network representativeness, or the degree to which the data collected accurately and precisely represent, in this case, pollutant impacts on a population. Uncertainty in this arena can be controlled through the selection of appropriate boundary conditions, such as, the monitoring area, the number and location of sampling sites, the sampling time period, and the frequency of sampling. Measurement uncertainties include errors associated with the measurements themselves and with the handling and processing of the samples. A quality assurance program is used to control and quantify measurement uncertainty to an acceptable level through the use of various quality control and evaluation techniques. The data quality indicators most important in determining total measurement uncertainty are: precision, accuracy, bias, and detection limits. These indicators are specifically defined by measurement quality objectives that, in turn, specifically define criteria for each variable affecting these data quality indicators.

1.4. *Measurement Quality Objectives (MQOs).* The measurement quality objectives (MQOs) set the limits of certain variables affecting the data that will determine data acceptability. The United States Environmental Protection Agency (US EPA) has developed MQOs for a number of variables affecting data quality, which are found in the US EPA guidance documents.[14, 15] These variables for which MQOs have been developed include those for precision, accuracy, bias, etc. Additional and/or more stringent MQOs may need to be developed for a given project over and above those established by the US EPA in order to achieve the data quality objectives for a project. The MQOs established by the US EPA apply most specifically to long-term ambient monitoring programs. Test method studies that are short-term in comparison with routine long-term ambient monitoring programs will likely require additional and more stringent MQOs, e.g. 90% data capture rates for all monitored variables rather than the 75% rate per quarter required by the US EPA for 24-hour daily average PM monitoring. Wind storm driven particulate emissions monitoring will require hourly data in order to characterize dust sources and hourly data capture rates must be developed for associated measurement quality objectives. More generalized quality assurance protocols for ambient PM monitoring data collection are also found in the regulatory guidelines (40 CFR, Part 58).

Meteorological data is used to support the dispersion model and to evaluate the relationship between saltation flux (also referred to as sand flux in this document) and PM impacts. Dispersion modeling is conducted using federally-approved models in accordance with Title 40 CFR, Part 51, Appendix W. Specific data quality objectives for sand flux measurements are suggested based on previous studies, but must be tailored to the specific application by the user depending on the type of sand flux measurement device that is used.

Appendix A includes a list of required and optional PM, meteorological and sand flux measurements needed to apply the windblown dust OTM. In Appendix B, the MQOs for each of the measurement parameters needed for the OTM are listed for PM, meteorological and sand flux monitoring. Most MQOs follow US EPA guidance for ambient measurement parameters. Appendix C contains the MQOs for sand flux monitoring, which is not a routine measurement used in air monitoring programs.

2.0 Summary of Method

2.1. *Principle.* During wind erosion events sand-sized particles creep and saltate across the surface, and finer dust particles are lofted. These events can cause dust to be transported many kilometers downwind. This test method can be applied to determine dust emissions as PM_{10}, $PM_{10\text{-}2.5}$, or $PM_{2.5}$. Because saltating particles move relatively short distances during a wind event, measurements of horizontal sand flux indicate the amount of wind erosion taking place near measurement sites. This test method is based on theoretical and experimental evidence that the vertical flux of dust is proportional to the horizontal flux of sand-sized particles. A schematic drawing of the saltation and dust production process is shown in Figure 1.

2.2. *History of the Methodology.* Shao, et al.,[3] theorized that the ratio of vertical dust emissions to horizontal sand flux tends to be constant for soils with the same binding energy. However, the binding energy of soils with similar texture and chemistry changes if surface moisture and temperature cause the soil to become more erodible or to form a crust and become stable. Long-term wind erosion studies at Owens Lake (1999-2010)[1,4] and Mono Lake (2009-10)[2] in California found that the ratio of dust emissions to sand flux changed seasonally for given surfaces. These studies compared hourly sand flux to the difference between upwind and downwind PM_{10} concentrations using dispersion models to determine changes in the seasonal ratio of dust emissions to sand flux. The hourly and seasonal ratios of the vertical flux of PM_{10} to horizontal sand flux were termed K-factors, K_f. These K-factors were used with sand flux measurements to calculate the vertical PM_{10} emission flux, F [g/cm^2-s], using Equation 1 as follows:

$$F = K_f \times q_{15} \qquad (1)$$

where q_{15} [g/cm^2-s] is the horizontal sand flux passing through a square centimeter plane at 15 cm above the surface, and K_f is a non-dimensional proportionality constant that is calculated from a dispersion model. Note that size-specific K-factors can be calculated for PM_{10}, $PM_{10\text{-}2.5}$ or $PM_{2.5}$, depending on the type of particulate monitor used for PM measurements. These studies also found that different soil textures and chemistries can affect K-factors. This resulted

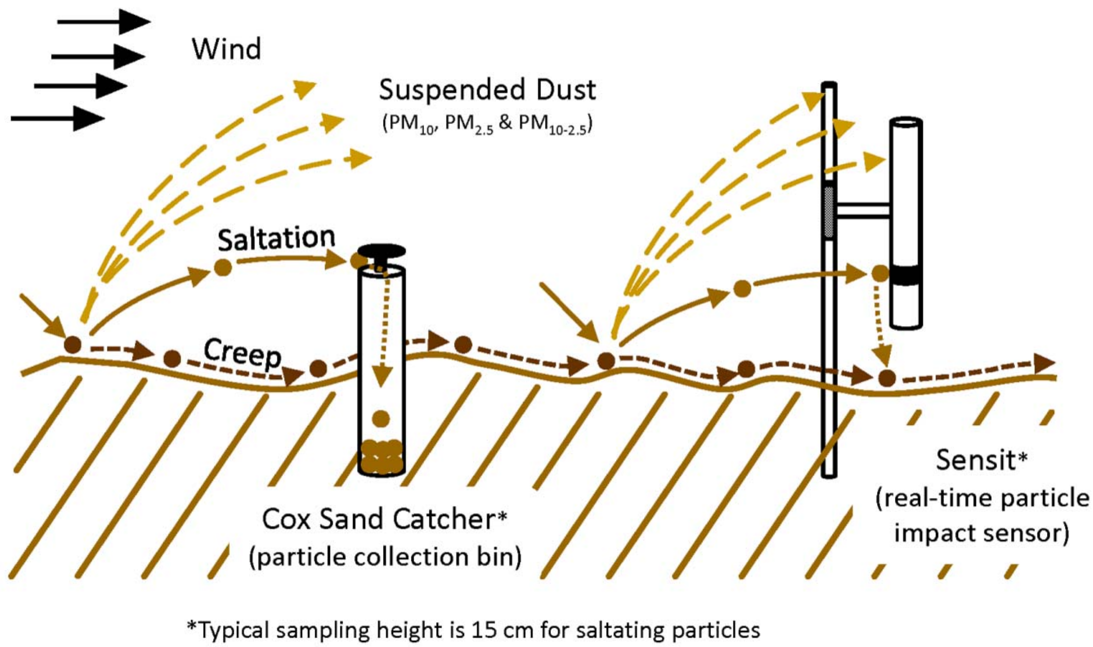


Figure 1. Schematic drawing of the saltation and dust production process for windblown dust.

in developing K-factors for different areas based on soil characteristics. This improved the estimated PM_{10} emissions by applying both spatial and temporal K-factors to Equation 1.[1,2,4]

2.3. *Sand Flux Measurements.* This test method requires two instruments to measure sand flux; one to measure the total sand catch during a collection period (e.g. month) and another to time-resolve the sand catch over the sampling period to determine the hourly sand flux. Cox Sand Catchers (CSCs) and Sensits, or equivalent instrument(s) capable of time resolving sand flux are required for use with this test method. The optional use of other sand flux measurement instruments, such as the BSNE (Big Springs Number Eight) is discussed in Section 13 of this document.

2.3.1. Cox Sand Catchers (CSCs) are manufactured by the Great Basin Unified Air Pollution Control District in Bishop, California and have been used extensively with this test method to measure sand catch. The inlets are placed at a 15 cm height above the surface in the dust source area. Sample tubes are collected about once a month for weighing in the laboratory.

2.3.2. Sensits are manufactured by the Sensit Company in Portland, North Dakota.[5] They are the only instrument that have been used successfully with this method to time-resolve hourly sand flux. Sensits use a piezoelectric crystal similar to a microphone to continuously detect and measure saltation activity as particle count and kinetic energy. These Sensit readings are proportional to the mass flux of particles. Sensits are co-located with CSCs, which measure the mass sand flux over long periods of time, such as weeks or months. Hourly Sensit readings are then used to time-resolve the CSC sand catch for the sampling period to determine hourly sand flux. Because horizontal sand flux decreases with height above the surface it is important that CSC and Sensit measurements be taken at the same height at all locations to ensure consistency in the results. It is recommended that the sensor of the Sensit and CSC inlet both be centered 15 cm above the surface.

2.4. Particulate Matter Monitoring. Federally-approved ambient particulate matter monitors capable of collecting hourly data are required for this test method. The US EPA maintains a list of designated reference and equivalent method monitors on their website at http://www.epa.gov/ttnamti1/criteria.html.[5] Studies using this method[1,2,4] have used TEOM PM_{10} monitors with good success (method number EQMP-1090-079). Other federally approved monitors capable of measuring hourly PM concentrations should also work with this method. This could include beta-gauge and beta attenuation type monitors or others that are capable of measuring hourly concentrations for PM_{10}, $PM_{10\text{-}2.5}$ or $PM_{2.5}$.[5]

2.5. *Meteorological Monitoring*. A 5 to 10-m meteorological tower is required for this test method. The meteorological tower should be located near the study area and equipped to measure and record hourly average data for scalar wind speed and direction as well as sigma-theta. Vector wind speed data is not required for the model inputs for this method. Other optional meteorological parameters such as solar radiation, precipitation and temperature may be measured. The tower should be sited and the data collected in accordance with federal monitoring guidelines as described in US EPA Volume IV.[15]

2.6. *Dispersion Modeling*. The AERMOD or CALPUFF dispersion models are US EPA-approved models that are used to support air quality analysis for new sources and State Implementation Plans in the US. Both dispersion models have worked well with this test method. Dispersion models are applied following US EPA modeling guidance (40 CFR, Part 51, Appendix W). AERMOD is a steady-state plume dispersion model suitable for smaller modeling domains, while CALPUFF is commonly applied to near-field dispersion and long-range transport situations where the three-dimensional qualities of the wind field are important.

2.7. *K-factors*. The dispersion model is used to calculate K_f using PM emissions from Equation 1 assuming an initial K-factor, $K_i = 5\times10^{-5}$, which has been determined to be a good initial K-factor value that typically range from 1×10^{-5} to 10×10^{-5} for loose sandy soils.[1] Hourly K-factor values are then refined in a post-processing step to determine the K-factor value that would have made the hourly modeled concentration, C_m, match the observed hourly concentration, C_o, minus background, C_b using Equation 2 as follows:

$$K_f = K_i\left(\frac{C_o - C_b}{C_m}\right) \qquad (2)$$

K-factors are calculated for every hour with active sand flux in areas upwind of a PM monitor. Hourly K-factors are screened to remove hours that do not have strong source-receptor relationships between the active dust source area and the downwind PM monitor. Screening criteria exclude hours for K-factor calculation when the dust plume misses the PM monitor, as well as hours when the monitor is near the edge of a dust plume. Because the edge of a dust plume has a very high concentration gradient, a few degrees difference in the plume direction could greatly affect a calculated K-factor. Examples of K-factor screening criteria include: hourly modeled and monitored PM_{10} are both greater than 150 µg/m^3, and sand flux is greater than 2 g/cm^2-hr in at least one sand flux site that was located within ±15º upwind from a monitor site. The ±15º wind direction screen from the sand flux site to the PM monitor site provides a 30º wind direction cone that helps to account for lateral plume dispersion as the dust travels downwind toward the monitor. These screening criteria may be modified by the user to ensure that enough hourly K-factors pass the screening criteria to yield reasonable results. For instance, in areas that have less wind erosion activity the screening criteria might be lowered to hourly modeled and monitored PM_{10} are both greater than 50 µg/m^3, and sand flux is greater than 0.1

g/cm^2-hr in at least one sand flux site. This will allow more data to be used to calculate hourly K-factors.

2.8. *PM emission determination.* The final step in the test method is to calculate seasonal K-factors using the screened hourly K-factors. These K-factors are based on the geometric mean hourly K-factor for a user-defined period or season. The geometric mean is appropriate for this purpose because the hourly K-factors tend to follow a log-normal distribution curve. Seasonal K-factors are used with Equation 1 to estimate hourly PM emissions. The framework of the windblown dust emissions test method is shown as a process flow diagram in Figure 2.

3.0 Definitions

3.1. Dust refers to particulate matter (PM) less than 10 microns (PM_{10}), less than 2.5 microns ($PM_{2.5}$), and coarse particles ($PM_{10-2.5}$).

3.2. Emission flux refers to the upwardly directed PM mass in terms of mass per area.

3.3. K-factor refers to the ratio of the vertical dust flux to the horizontal saltation flux.

3.4. Saltation refers to the wind-activated hopping and skipping movement of sand-sized particles above the soil surface.

3.5. Sand flux refers to the amount of sand-sized particles passing perpendicular through a vertical plane; also referred to as saltation flux. Sand-sized particles include individual sand grains as well as agglomerated soil particles.

3.6. Sand catcher refers to devices, such as the Cox Sand Catcher that are used to measure saltation flux over a given period (e.g. monthly sample collection).

3.7. Sensit refers to an electronic sensor that provides a relative reading of the sand flux over time. It is used to time-resolve sand catch mass using the linear relationship between Sensit readings and saltation flux to determine hourly sand flux rates.[6]

4.0 Interferences

4.1. *Unmonitored Sources of PM.* Dust sources that are not included in the background concentration as measured at the upwind monitor or not included in the model may bias hourly K-factors. This could include adjacent dust source areas that are not included in the sand flux monitoring area and miss the upwind monitor, but impact the downwind monitor site. Since the accuracy of K-factors in Equation 2 relies on good model predictions that correlate with PM monitor concentrations at the downwind site, it is important that all PM sources that contribute to downwind monitor concentrations are included in the dispersion model. If sources other than windblown dust are contributing to downwind PM concentrations, they can be included in the background concentration if they are much smaller than the contribution from the monitored windblown dust source areas (e.g. less than 20% of the total ambient PM impact), or included as separate PM sources in the dispersion model.

4.2. *Non-representative Winds*. The meteorological tower and PM monitor should be located to avoid any structures or topographical features that may interfere with wind flow patterns between the dust source area and the downwind PM monitor.

4.3. *Weak Source-Receptor Relationships*. The source-receptor relationship is the link between the source of PM emissions at the sand flux measurement sites and the impact at the

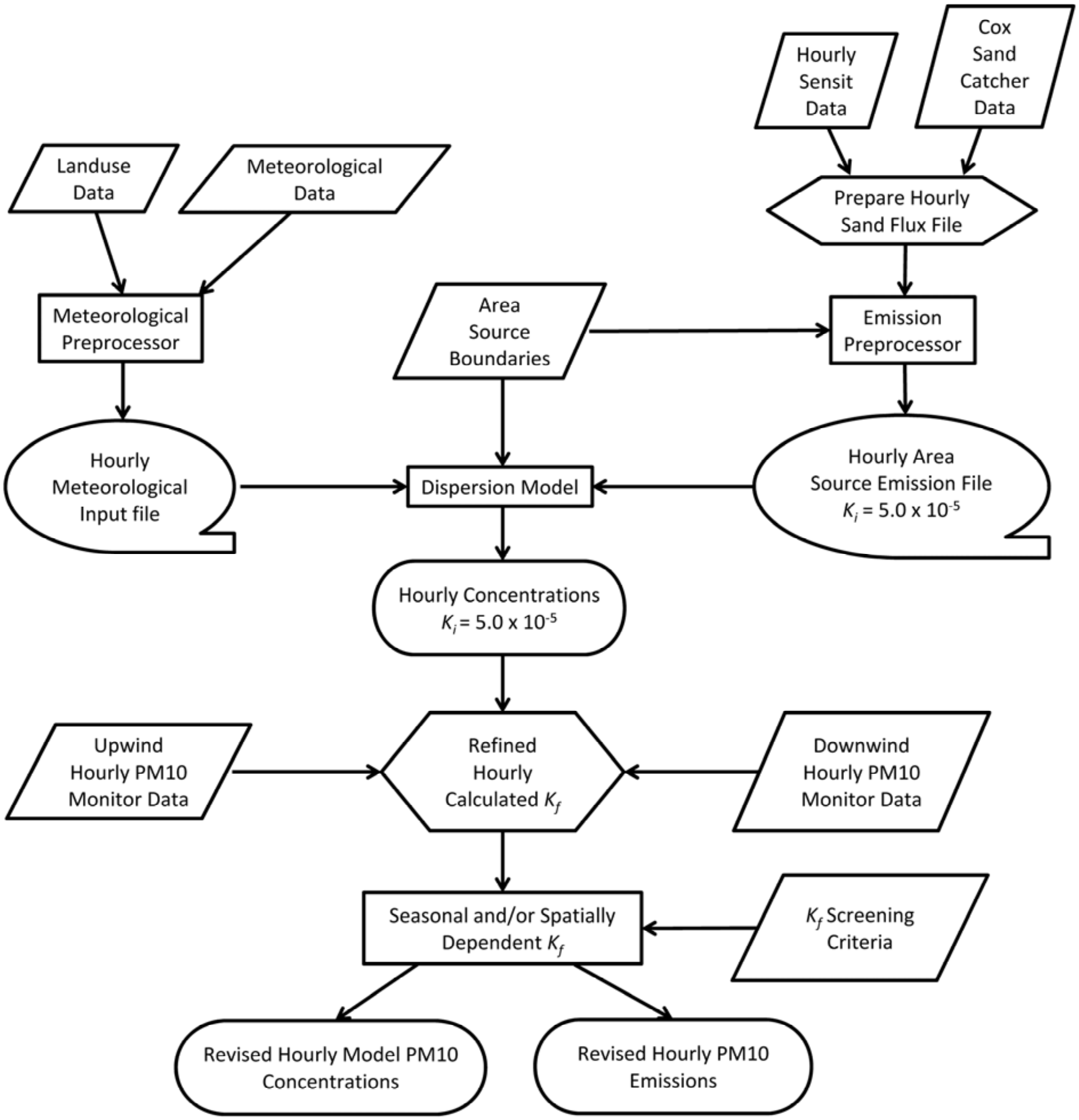


Figure 2. Process flow diagram for the windblown dust test method.

model receptor location identified as the downwind ambient PM monitor site. The screening of hourly K-factors for wind direction, source strength and monitored impact is intended to focus the hourly K-factors on the values that have the strongest source-receptor relationship. The screening criteria are left to the user to decide. See Section 2.7 for examples of K-factor screening criteria. Because some areas may have smaller source areas or lower PM concentrations, overly restrictive screening could result in no usable results. After the K-factors are determined, the best way to evaluate the validity of the emission estimates for the dust source areas is to utilize the new values using Equation 1 in the dispersion model and compare model predictions to monitored concentrations.

5.0 Safety

5.1. *PM Exposure.* As a health precaution, project personnel should avoid exposure to high PM. Windblown dust source areas can have hourly PM_{10} levels exceeding 10,000 µg/m^3 during a high wind event. All of the monitoring equipment is intended to be left in place during an event and should require no site visits except for routine maintenance for the PM monitor and monthly visits to the sand flux sites to collect sample tubes and to download Sensit data. These site visits should be done when wind speeds are below the threshold to generate dust.

5.2. *Let someone know where you are going if you will be in a remote location.* If projects are conducted in remote locations, field personnel should let someone know where they will be going and when they expect to return. Project sites can be in locations with no cell phone reception. Personnel may require assistance in the case of an emergency, such as having a vehicle breakdown or getting stuck in the sand.

6.0 Equipment and Supplies

6.1. *Sand Flux Sample Collection.* Figure 3 shows an example of a CSC and Sensit sampling site at Mono Lake, CA.

6.1.1. Cox Sand Catchers & Sampling Tubes – The number of CSCs to be deployed will vary with the size and surface uniformity of the study area. Replacement sampling tubes will be needed for each CSC site. CSCs should be installed using an auger to drill a hole in the soil to fit the CSC sample tube casing. In sandy soil it is helpful to wet the soil in the upper portion of the hole before drilling to avoid soil collapse. CSCs can be obtained from the Great Basin Unified Air Pollution Control District in Bishop, California or the design specifications provided in Figure 4 can be used to construct your own CSCs.

6.1.2. Sensits – The number of Sensits to be deployed will vary with the size and uniformity of the surface in the study area. All Sensits must be collocated with CSCs, however, to reduce equipment costs and to increase spatial sand flux information, Sensits may be used to time-resolve sand flux for multiple nearby CSC sites that have no Sensits. Each Sensit must have a support structure to suspend the sensor at 15 cm above the surface. The support structure should be positioned so it doesn't interfere with saltation particles moving in the directions for expected high winds. Information on installing and operating Sensits can be found at http://sensit.org/default.aspx.[6]

6.1.3. Data Loggers – Each Sensit site must have a data logger to record time, kinetic energy and particle count readings from the Sensits. This data is stored in 5-minute and hourly increments. Other useful data includes voltage for the power supply.

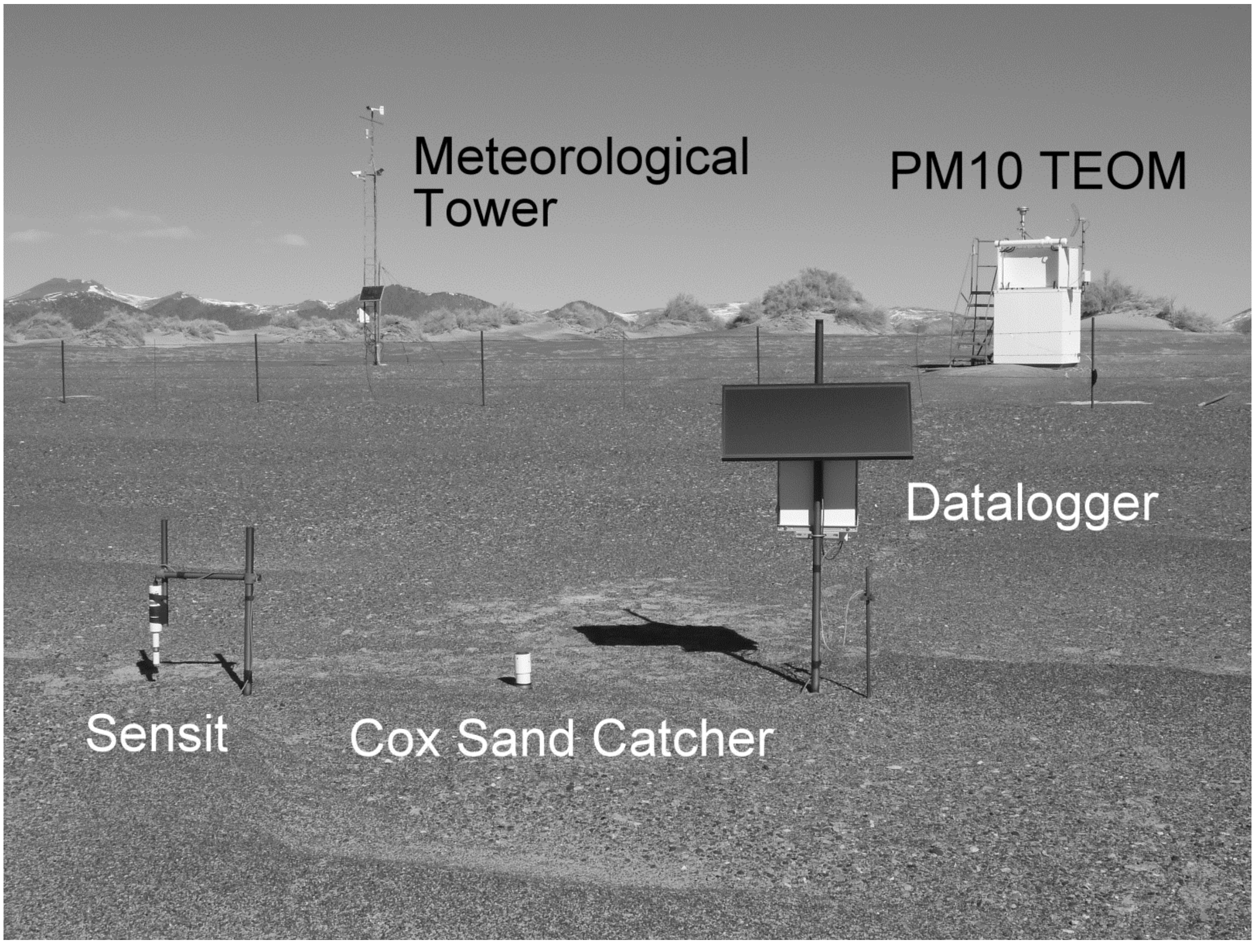


Figure 3. Sand flux site and dust monitoring equipment at Mono Lake, CA.

6.1.4. Power Supply; battery & solar panel – Each Sensit site must have a power supply for the data logger and Sensit. Solar panels with 20 amp-hr batteries are generally used to provide power at Sensit sites.

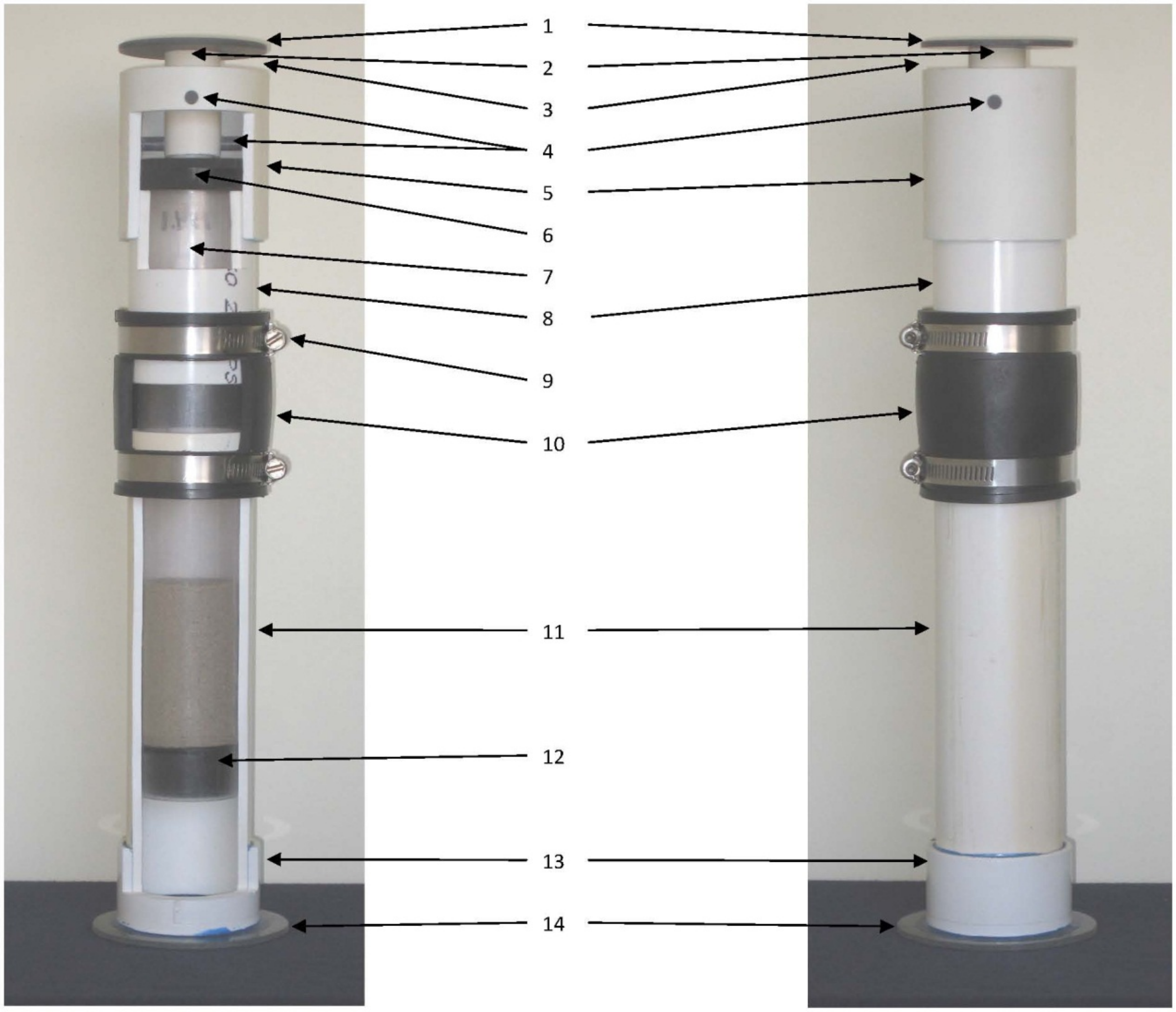
6.1.5. Height Adjustment Tool - A small tripod with flat feet (Figure 5) is used to measure the height of the CSC inlet and the sensor ring of the Sensit after each collection period and if necessary, to readjust the center of the CSC inlet and Sensit sensor ring to 15 cm above the surface at the start of the next collection period.

6.1.6. Field Scale – A scale capable of measuring mass up to 2 kg is used to obtain approximate CSC sample tube collection weights to the nearest 1 gram in the field.

6.2. *Sample Recovery*

6.2.1. Balance – A balance capable of measuring mass to ± 0.1 g is needed to weigh CSC samples in the lab. The tare weight of the CSC collection tube and sample may be as much as 2,000 g. Large samples may have to be split to obtain total weights.

Oven, drying pans & distilled water – Wet or moist CSC samples must be transferred from the collection tube to a pan and dried in the oven to obtain a dry sand catch mass. Distilled water is used to wash the sample from the tubes.



Reference #	Feature	Description
1	Roof	1/8" thick by 2 3/4" diameter PVC sheet
2	Roof Support	3/4" schedule 40 PVC pipe 2" in length
3	Sample Inlet Opening	1 cm from bottom of roof to top of PVC coupling. Tolerance is 0.5 mm.
4	Support Pins	1/4" diameter PVC rod glued in place
5	Head	2" schedule 40 PVC coupling, specify long coupling approximately 2 3/4" in length
6	Catch Tube Seal	rubber shank washer cut to fit
7	Catch Tube	2" diameter clear plastic soil sample tube variable length to fit application*
8	Connecting Pipe	2" schedule 40 PVC pipe** 3 1/2" in length
9	Stainless Pipe Clamp	
10	Adjustment Coupling	2" diameter rubber plain and flexible pipe coupling 3 1/2" in length
11	Body	2" schedule 40 PVC pipe** variable in length to fit application, 25" for 2' CSC
12	Catch Tube Stopper	rubber stopper or plug
13	Bottom Cap	2" schedule 40 PVC cap with a flat top
14	Bottom Plate	1/8" thick by 3 7/8" diameter PVC sheet

*Note: The Catch Tube shown here is partially filled with sand.

**Note: The inner diameter of PVC pipe varies with manufacture. Make sure the sample catch tube slides freely into the pipe before purchasing.

Figure 4. Cut-out of Cox Sand Catcher and construction specifications.

Figure 5. A Height Adjustment Tool is used to measure the height of Sensits and CSCs and to adjust the sensor and inlet height to 15 cm above the soil surface.

6.3. *PM Monitors*

6.3.1. TEOM – Previous studies have used PM_{10} TEOMs.[1,2,4] Other US EPA-approved continuous PM monitors, such as beta attenuation monitors can also be used.[5] PM monitors may measure PM_{10}, $PM_{2.5}$ or $PM_{10-2.5}$. At least two PM monitors are recommended; one that can serve as an upwind monitor to measure background concentrations and another for measurements downwind from the source area. In cases where downwind concentrations are very high relative to background concentrations and there are no other significant PM sources that contribute to the study area, the upwind background monitor does not necessarily have to be near the study area. Instead, an average regional background concentration representative of the study area under high wind conditions can be used in Equation 2. To determine an average regional background concentration, hourly PM monitor data from nearby sites should be screened to average PM concentrations when winds are high (hourly average above 5 m/s at 10-m height) and from wind directions that are not impacted by other dust sources that would not be representative of air upwind from the source area of interest. This information may be obtained from the state or local air pollution authority if they operate hourly PM monitors. PM monitors that are based on light-scattering measurement methods are not recommended for use with this test method due to variations in mass concentration readings caused by changes in particulate matter composition and particle size distribution.[7]

6.3.2. Data Logger – a data logger is needed to record hourly average PM concentrations if the PM monitor does not store hourly PM data.

6.3.3. Power Supply – US EPA-approved continuous PM monitors generally require line power or a large photovoltaic power system to provide sufficient power to operate. Propane powered generators can also be used for short-term sampling at remote locations.

6.4. *Meteorological Measurements*

6.4.1. Met Tower – A 10-m meteorological tower is recommended, but a lower height tower (e.g. 5 m) can also be used to reduce cost.

6.4.2. Wind Vane – a wind vane is needed to determine wind directions and sigma-theta for the study area and for the K-factor screening criteria.

6.4.3. Anemometer – wind speed is needed for the dispersion model and for the K-factor screening criteria.

6.4.4. Rain Gage – Precipitation data may help in the evaluation of changes in surface conditions that could affect wind erosion.

6.4.5. Data Logger - a data logger is needed to record hourly average wind speed, wind direction and other parameters. Note that 5-minute average wind speed and wind direction data, along with hourly gust information can be helpful in comparing sand flux measurements to wind speeds when checking for possible data errors and for evaluating threshold wind speeds.

6.4.6. Power Supply – solar panels with 20 amp-hr batteries are used to provide power for the data logger and other instruments.

6.4.7. Temperature, solar radiation, cloud cover – These are optional on-site measurement parameters used with the dispersion model to determine the meteorological stability class, since the stability class becomes neutral with moderate to high winds. These optional measurements may be substituted with data from a representative regional site. A pyranometer is used to measure solar radiation.

6.5. *Dispersion Modeling and Data Reduction Software*

6.5.1. Dispersion Model – The AERMOD and CALPUFF dispersion modeling systems (40 CFR, Part 51 Appendix W) have been used successfully with this test method for windblown dust.[1,2,4] Both modeling systems have refined modeling routines to simulate near-field impacts from fugitive dust source areas.

6.5.2. Data Reduction – A spreadsheet or database software program is needed to store data for sand catch, Sensit readings, PM monitor concentrations, wind speed, wind direction, dispersion model outputs and other data collected as part of the study. The program is used to calculate and screen hourly K-factors and to calculate PM emissions.

7.0 Sample Collection, Preservation, Storage and Transport

7.1. *Preliminary Determinations - Prepare a Network Monitoring Plan.* The complexity of the network design for this test method can range from single sand flux, meteorological and PM monitor sites to estimate emissions from a small dust source area, to a network of over 100 sand flux sites, with multiple PM monitor and meteorological sites to measure dust from source areas in a 100 km^2 area. The number of monitoring sites should be tailored to the resources available for the project. More measurements will improve the accuracy of the results, but good emission estimates can still be derived from networks with fewer sand flux monitor sites. The accuracy of the emission estimate primarily relies on the downwind PM monitor. If there are 6 or more PM monitors being used for the project, a collocated PM monitor site should be established at the site of maximum impact. It is important to operate collocated monitors at this location to enhance the defensibility of the data being collected. Sand flux measurements provide inputs to the model based on the relative level of erosion activity in each area and what time it occurred. By collecting samples from multiple sand flux sites, a better representation of the area-wide average can be achieved. Ideally, the sand flux measurement from each site would be an average sand flux rate for the area it represents. However, because the dispersion model uses the downwind PM monitor to refine the PM emission estimates, any measurement bias in the sand flux measurement as compared to the actual average will be compensated for by adjustments in the K-factor to yield the correct PM emissions.

7.1.1. Sensit and CSC Monitor Locations - The sand flux monitoring area should include all significant windblown dust source areas between the upwind and downwind PM monitor site that could impact the downwind monitor. Significant dust source areas outside the monitoring area can be excluded in the K-factor analysis by screening the hourly data to only analyze hours when the wind direction is from the study area to the PM monitor site.

Sensits and CSCs should be collocated at sites 100 to 1,000 m apart. The density of the sand flux monitoring network is left to the user depending on available resources for the project. Sites can be placed in a grid pattern for random sampling or can be placed in locations to represent areas with different surface characteristics or different points of investigative interest.

Each Sensit/CSC pair must have a designated source area boundary that is represented by that site. The boundaries of those areas can be based on evenly spaced grids, on different surface conditions or topographical features, or on observed dust source area boundaries if such evidence is available for erosion events. Additional CSC units can also be placed in the field without collocated Sensits to provide better spatial information. Source area boundaries must be designated for each CSC site and hourly sand flux from CSC-only sites should be time-resolved using the nearest Sensit.

Collocated studies with the Cox Sand Catchers (CSC) have been conducted that demonstrate the precision of the instruments to be within ±3%.[1] However, the precision of the CSCs and Sensits is difficult to determine in an area-source fugitive emissions study. It is more likely that variability in the measurements is attributable to variability in the source emissions impacting the monitors than in the monitoring devices themselves. Since precision is effectively determined by comparison of the modeled concentrations calculated from Sensit/CSC data with the monitored data collected at the PM monitoring stations, the need for collocated Sensit/CSC sand motion monitors is not necessary.

7.1.2. PM Monitor Locations - After reviewing pre-existing wind speed and direction data for the study area, the predominant wind directions should be determined for high wind events. PM monitors should be located upwind and downwind of the sand flux-monitored source area boundary. There should be no significant sources of dust other than the source area being monitored between the PM monitor and the dust source area boundary. The downwind monitor can be in or near the edge of the dust source area. If there is a lack of significant dust sources impacting the upwind side of the study area, and the downwind PM concentration is expected to be much higher than the upwind concentration, the upwind monitor concentration can be represented by a regional background concentration. This regional background can be estimated from the hourly average value during high wind events in areas not affected by windblown dust.

7.1.3. Meteorological Monitor Location - A 5 to 10-m meteorological tower should be installed in or near the study area. It must be equipped to measure and record hourly average scalar wind speed and direction and sigma-theta. As mentioned in the equipment description other optional meteorological parameters such as solar radiation, precipitation and temperature may be measured.

7.1.4. Sample Network - Figure 6 shows an example of a windblown dust monitoring network at Mono Lake, CA. It consists of 25 CSC sites, 2 Sensits, one meteorological tower and one PM_{10} TEOM. The site is designed to monitor southerly windblown dust events. The boundaries of dust source areas are based on soil texture and topographical features caused by water eroded cut-banks on the playa. Sand flux for each of the CSC sites is time-resolved based

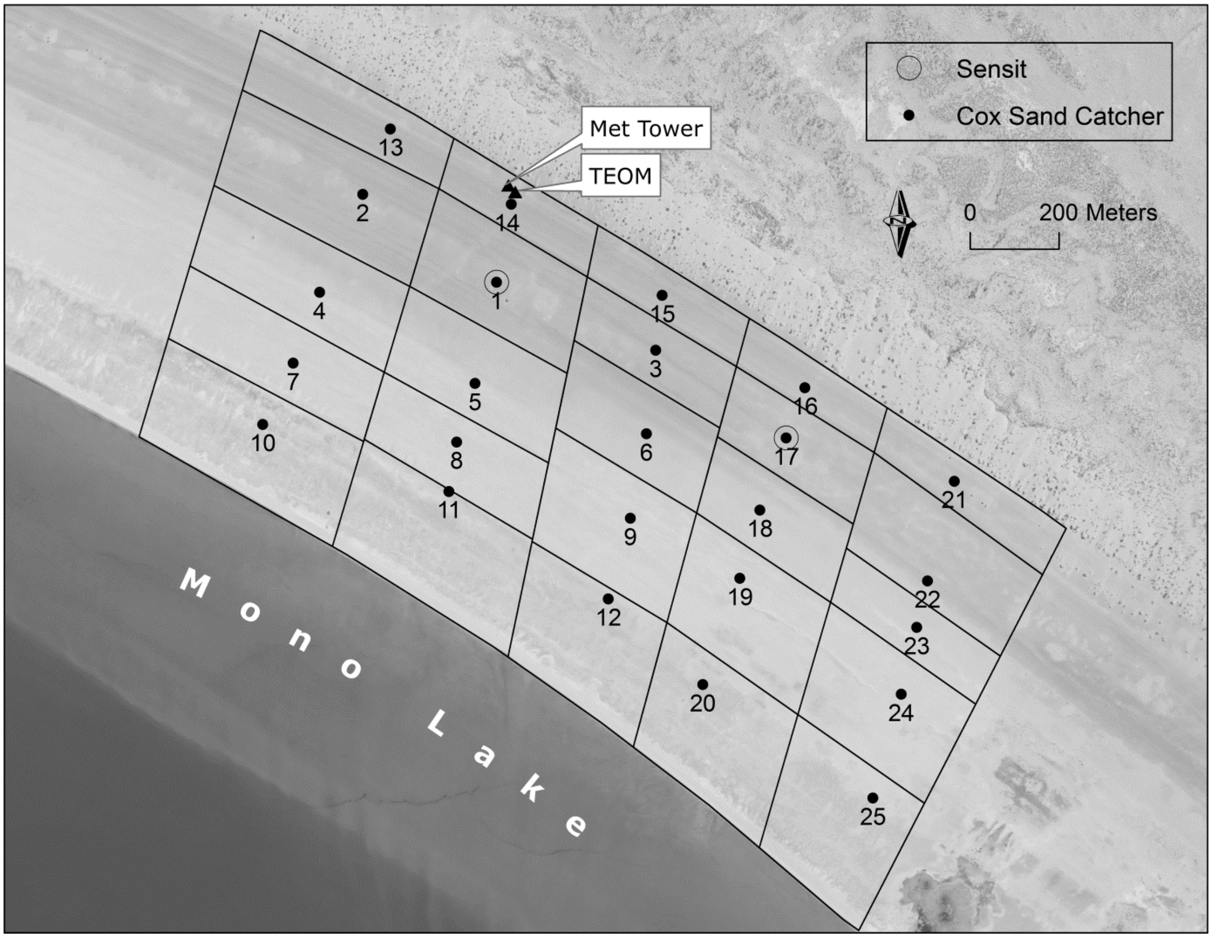


Figure 6. Example windblown dust monitoring network at Mono Lake, CA. The upwind PM_{10} monitor is a regional background site located southwest of the lake. (July 2009 – June 2010)

on the particle count data from the nearest Sensit. The downwind PM monitor and meteorological tower are inside one of the downwind dust source areas. The upwind background PM concentration is based on the average PM_{10} value during hours with high winds (>7.5 m/s at 10-m) from the south at a site located on the southwest side of Mono Lake.

7.2. *Pre-test Preparation.*

7.2.1. Meteorological Instruments – Calibrate anemometer, wind vane, and temperature gage in accordance with US EPA monitoring guidelines in EPA Volume IV. [15] Check data logger connection and initiate data collection.

7.2.2 PM Monitor – Calibrate PM monitor in accordance with US EPA monitoring guidelines found in 40 CFR, Part 58, Appendix A, and in US EPA Volume II[14]. Check data logger connection and initiate data collection.

7.2.3 Cox Sand Catchers – Record empty tare weight of sand catcher sampling tubes on a laboratory documentation form.

7.3. *Field Check for Sand Flux Measurement.*

7.3.1. *Cox Sand Catchers* – Install empty sample tube and check and/or adjust inlet height to 15 cm using the Height Adjustment Tool and initiate sample collection. Verify that the sample tube number corresponds to the site number on the field form. Record date and time of new tube installation and surface condition information on field documentation form. A sample field documentation form is shown in Figure 7. A blank field form is included in Appendix D.

7.3.2. *Sensit* – Check that the Sensit is responding by tapping on the sensor. Check data logger connection and power supply. Check and/or adjust sensor height to 15 cm above the surface using the Height Adjustment Tool. Initiate 5-minute sampling and data logger recording for the following parameters: Date and time, particle count (5-minute total), kinetic energy (5-minute total), and power supply voltage (reading every 5-minutes).

7.4. *Sample Recovery.* Sand captured in the CSCs is weighed both in the field and later in the laboratory to the nearest tenth of a gram. Field personnel should visit each site monthly or more often to avoid over-filling the CSC sample tubes. Site visits should only be conducted at times when wind erosion is not taking place. Site visits during an event can disturb the soil near the sand flux site, and can compromise Sensit data if a technician taps on the Sensit or interferes with data collection.

The following procedures are used when collecting the CSC samples and downloading Sensit data:

1) Park field vehicle 10 m or more away from the site and walk the remaining distance to the sampling site. Field personnel must access all Sensit and CSC sites from a direction that will minimize upwind surface impacts near the sampling sites.
2) Record surface conditions.
3) Measure and record the inlet height above the surface to the middle of the inlet.
4) Lift off the CSC inlet and remove the sample collection tube.
5) Verify collection tube number corresponds to site number on the field form.
6) Weigh and record the gross weight of the collection tube and sample to the nearest 1 gram using a field scale.
7) If any soil material is visible in the tube, seal the collection tube and place it in a secure place or in a tube rack for transport to the lab. If no soil material is visible, note this on the collection form and reuse the collection tube for the next sampling period.
8) Place a clean collection tube (if appropriate) in the CSC and record the collection tube number.
9) Replace the CSC inlet and adjust the height to 15 cm (±1 cm).
10) Download Sensit data from the data logger to a data storage module.
11) Measure and record the Sensit sensor height above the surface to the center of the sensor using the Height Adjustment Tool, and adjust if necessary to 15 cm.
12) Perform a field operational response test on the Sensit by tapping on the sensor during each visit. Replace the Sensit if it does not show a response.
13) Return the CSC sample tubes to the laboratory for weighing on a bench-top lab scale.
14) Before weighing, visually determine if the CSC sample catch is wet or dry. Catches are considered dry if the sample appears loose and moves easily inside the catch tube when the tube is tilted on its side and shaken. Catches are considered wet if there is standing water in the sample catch tube or if darker layers in the catch tube appear moist and do not shift when the sample tube is tilted and shaken. Layers in a sample tube that are

COPY

Mono Lake
Sensit/CSC Field Form

Page 1/3

Technician: Chris Howard + Mike Slater Date (mm/dd/yyyy): 06/01/2010

Site #	Time (PST)	Pre-Sensit Height, cm	Sensit Response	Final Sensit Height, cm	Pre-CSC Inlet Height, cm	Field Cal Weight, kg	CSC Full, kg	CSC Tare, kg	Final CSC Height, cm
13	08:27	–	–	–	15	0.101	1.459	.243	15
2	08:39	–	–	–	16	0.101	1.429	.242	15
4	08:46	–	–	–	17.5	0.101	.735	.264	15
7	08:55	–	–	–	17.75	0.101	.507	.236	15
10	09:05	–	–	–	15	0.101	.335	.241	15
11	09:14	–	–	–	15	0.101	.370	.265	15
8	09:20	–	–	–	15	0.101	.776	.242	15
5	09:24	–	–	–	15.5	0.101	.807	.236	15 ~~14~~.5
1	09:42	15	yes/yes	15	~~16~~ 14	0.101	1.524	.333	15
14	09:58	–	–	–	15	0.101	1.325	.328	15
15	10:50	–	–	–	15	0.101	1.036	.334	15
16	10:58	–	–	–	15	0.101	1.724	.332	15

Marble Rankings: 0=No Crust 1=Complete Damage 2=Indent or Surface Damage 3=No Damage 4=Wet

Photo	Site #	Rank	Surface Description	Comments and Maintenance
1	13	0	dry sandy gravel	
2	2	0	dry beach sand	
3	4	1	50% salt crusty, no growths, damp	CSC too high, swapped for shorter riser
4	7	2	wet salty crust 50% 50% sandy (wet)	CSC too high - swapped for shorty riser
5	10	2	100% salt crust - small cauliflower	old tare .250 - note taken
6.	11	2	~~[illegible]~~ salty crust 90% damp sand below	
7	8	0	20% salt crust, 80% moist sand	
8	5	0	damp sand w/20% salty crust	Re-dug CSC
9	1	0	dry sand	battery 14.068
10	14	0	dry pebbly sand	
11	15	0	dry pebbly sand	
12	16	0	dry pebbly sand	Swapped bad (cracked) tube (3')

Delivered By: Date:
Received By: Date:

Figure 7. Sample field documentation form. A blank form is included in Appendix D of this OTM.

cemented and do not shift when the tube is tilted and shaken indicate that the sample was likely wet at some point. These are considered wet catches and must be dried before the sample is weighed.

15) Drying procedures for wet catches. Remove samples from the catch tube prior to drying. The sample catch tubes can melt if placed in the oven overnight. Use a brush to clean out the tube and make sure all the sample is removed from the tube. If possible use tweezers to remove any debris that may be in the sample, e.g. bugs and leaves. Sometimes rinsing the sample from the tube is necessary in order to get the sample out of the tube. Use distilled water and catch any water used to rinse the sample catch tube and dry it along with the rest of the sample. This will ensure that no catch was lost by rinsing. The sample may either be air-dried or placed in a drying oven until it has reached a constant weight when cooled. 24-hours in an oven at 105º C is usually adequate to dry wet samples. The oven temperature during the drying process must not exceed 110º C (230º F) in order to not drive off crystallographic water from the minerals present.
16) Weigh dry collection tubes and dried samples on a calibrated bench-top scale in the laboratory to the nearest 0.1 g.

7.5. *Chain of Custody.* Each field and laboratory form must be initialed and dated by the field and laboratory technician during each site visit and sample transfer to the laboratory.

7.6. *Maintenance Log.* Keep a log in the technicians field notebook of all repairs, maintenance, or replacement of Sensits or CSCs, and data logger equipment.

7.7. *Meteorological and PM Data.* Download PM monitor and meteorological data to a data storage module every site visit and at least once per month. A better alternative would be to collect the data via a telemetry system on a frequent, e.g., daily, basis.

8.0 Quality Control

8.1. *Review Sensit and Sand Flux Data.*

8.1.1. Review 5-minute Sensit data for missing records. Missing data may have been caused by low battery voltage or a data logger malfunction. Missing Sensit data from a site can be replaced by Sensit data from the next closest site to time-resolve CSC sand catch data.

8.1.2. Remove any Sensit data associated with tap response tests performed during site visits.

8.1.3. Check for anomalous data, such as non-zero Sensit readings during periods with low wind speeds that may be caused by something other than wind erosion. Note that sand flux may occur during hours with low hourly average wind speeds if there are significant wind gusts during that hour. This often happens at the beginning and end of a windy period when the hourly average wind speed may be low, but significant wind gusts occurred during that hour. If 5 minute wind speed and/or wind gust data was collected, this may also help reconcile non-zero sand flux that corresponded to periods with low hourly average wind speeds.

8.1.4. Check the Sensit reading to CSC sand mass ratio for each period to determine if the ratio is in the same range as previous sampling periods. Note that this ratio may vary based on the direction of the incoming sand flux due to non-uniformity in the Sensit sensor ring. It is helpful to maintain the Sensit sensor in the same compass direction to minimize changes in the calibration caused by the non-uniformity of the sensor ring. This measurement uncertainty is not considered significant, but large differences, such as an order of magnitude or more, may be an indication that the Sensit should be replaced. Each Sensit has a unique response to sand flux, which causes the ratio of sand flux to the Sensit particle count (or kinetic energy) reading to be different for each Sensit. Although Sensits manufactured in the same batch usually have similar responses, all Sensits should be treated as instruments with individual sand flux calibration factors. Sensit instruments should be tracked individually to characterize the ratio of the sand flux to Sensit reading.

8.1.5. Missing sand catch mass data can occur if the CSC sample tube is left in the field too long and it over-fills, or if the sample is spilled. If it is collocated with a Sensit, ratios for the Sensit reading to the CSC sand catch for other sampling periods at that site can be used to estimate hourly sand flux from the hourly Sensit readings. A minimum estimate of the hourly sand flux should be calculated based on the sand catch mass for the full sample tube. If the Sensit calibration method doesn’t yield a total sand catch for the sample period that is higher than the full sample tube mass, the minimum estimate from the full sample tube should be used instead of the Sensit calibration method. Any missing data that is replaced should be flagged in the database for future reference. If missing sand flux data is replaced with zero sand flux, the modeling analysis will associate zero emissions from this source area. If the emissions are significant as in the case of overfilled CSCs, this would affect K-factor calculations and emission estimates from each area represented by the sand flux sites.

8.2. *Review Meteorological Data.* Review wind speed, wind direction, sigma-theta and other meteorological measurements for missing records. Remove any data associated with audit/calibration checks. Check for possible anomalous data and investigate as needed.

8.3. *Review PM Data.* Review particulate matter data and check for missing data. Remove any data associated with audit/calibration checks. Check for possible anomalous data, such as high readings that may be associated with calibration checks or site visits and investigate as needed.

9.0 Calibration, Standardization, and Quality Assurance

9.1. *Quality Assurance Audits.* Calibration and standardization tasks may be conducted by staff operating the monitoring network on a routine basis. Quality assurance audits must be conducted by a qualified third-party not involved with the routine operation of the project utilizing standards that are separate from those used for routine calibration checks.

9.2. *Mass Measurements.* Check all lab balances before and after every weighing session using National Institute of Standards and Technology (NIST) Class F weights. Check field scales with NIST Class F certified weights before and after every field day, and during the day with a 100-gram weight at each sample site before weighing the sand catch and recording the weight on the field form. Check the bench-top balance in the laboratory with NIST Class F weights before sand catches are weighed. Record test weights on the balance log sheet in the laboratory. Calibrate and certify all balances at least once every year using a qualified third-party that can certify, adjust, and repair the balances.

9.3. *Meteorological Monitoring Station(s).* Verify the operation of all meteorological sensors using the procedures specified in US EPA QA Handbook Volume IV.[15] All sensors must be audited within 30 days of installation and every six months thereafter.

9.4. *Particulate Matter Monitoring Stations.* Monitors for particulate matter (PM) must be US EPA-certified equivalent method continuous monitors capable of providing hourly-resolved PM concentrations. The monitors must be operated and maintained, at a minimum, according to

US EPA guidelines for ambient monitoring provided in 40 CFR, Part 58, Appendix A and those found in the US EPA QA Handbook Volume II.[14] Equipment operators should be prepared to increase the frequency of routine maintenance activities based on the conditions under which the monitors are operated. It is not unusual for downwind monitors located near a dust source to measure hourly concentrations in the thousands or even tens-of-thousands of micrograms per cubic meter. In this case, maintenance activities such as inlet cleaning and filter change frequency must be increased, e.g. weekly PM inlet cleanings and filter changes after every storm event in order to ensure the collection of high quality defensible data.

9.5. *Dispersion Modeling.* The modeling effort shall be conducted following US EPA guidelines for dispersion modeling as provided in Title 40 CFR, Part 51, Appendix W.[17]

10.0 Data Analysis and Calculations

10.1. *Calculate Hourly Sand Flux.* Time-resolve mass measurements from CSCs with Sensit readings to calculate hourly sand flux at each site using Equation 3 as follows:

$$q_{i,c} = \frac{CSC_{p,c}}{1.2}\left[\frac{PC_{i,s}}{\sum_i^n PC_{i,s}}\right] \tag{3}$$

where,

$q_{i,c}$ = sand flux (at 15 cm height) for hour *i* at CSC site *c* [g/cm^2-hr]
$CSC_{p,c}$ = sand catch mass for period *p* at CSC site *c* [g]
$PC_{i,s}$ = Sensit particle count (or kinetic energy) for hour *i*, with *n* number of hours during period *p* at Sensit site *s* (closest Sensit to CSC site *c*) [counts]
1.2 = inlet area size of CSC based on BSNE comparison [cm^2]

10.2. *Review Hourly Sand Flux*. Perform quality control checks for missing data and anomalous sand flux estimates as discussed in Section 8.1.

10.3. *Dispersion Modeling*. Run the AERMOD or CALPUFF dispersion modeling system following US EPA modeling guidance (40 CFR, Part 51, Appendix W). The source area configuration for each dust source area is applied using boundaries of the source areas represented by each CSC configured to account for surface features and different soil textures as discussed in Section 7.1.1. PM_{10} emissions from each dust source are first estimated by applying the hourly sand flux in Equation 3 to estimate PM_{10} emissions in Equation 1 with an initial K-factor, $K_i = 5 \times 10^{-5}$. Prepare a meteorological data input file for the dispersion model of choice using scalar wind speed, scalar wind direction, and sigma-theta measurements. Regional upper air and cloud cover observations and/or local measurements of solar radiation and differential temperature would typically be necessary depending on the dispersion model selected for the analysis. Receptor locations for model predictions must include the downwind PM monitor site. Select dispersion model options according to the US EPA regulatory guidance associated with each model. Options specific to area source simulation and mass depletion should be selected on a case-by-case basis depending on the source to receptor relationship. A precise area source algorithm is suggested when the PM monitor is close to the emitting dust source. Dry deposition and subsequent depletion of mass from the dust plumes depend on the particle size distribution. The dry deposition option can be turned off if the user does not have size distribution data. For the very windy conditions on November 20, 2009 at Mono Lake, the downwind concentrations for 1, 3 and 10 micron particles would have been 99%, 80% and 76%, respectively of the concentrations without plume depletion. Particle size distribution data relevant for the source area should be collected if the dry deposition option is turned on in the model.

10.4. *Compile Monitoring Data and Initial Model Results*. Compile hourly data and initial model results in a database or spreadsheet data management system. Data shall include: date, hour, wind speed, wind direction, upwind PM concentration, downwind PM concentration, sand flux, and the initial dispersion model prediction of PM concentration for the downwind PM monitor location. Note that the upwind PM concentration is treated as the background concentration for K-factor calculations. This may be replaced by a representative regional background concentration for high wind conditions if an upwind monitor is not located adjacent to the study area. See Section 6.3.1. regarding calculating a regional background concentration.

10.5. *Calculate K-factors.*

Step 1: Calculate hourly K-factors in the data management system using Equation 2. Hourly PM concentrations upwind from the study area should be used in Equation 2 for background concentrations. However, an average background PM concentration for high wind conditions at nearby site(s) upwind from windblown dust areas can be used in Equation 2, if it can be considered representative of concentrations upwind from the study area.

Step 2: Screen the hourly K-factors to remove hours that did not have strong source-receptor relationships between the monitored dust source areas and the downwind PM monitor. Documentation of all screened hourly K-factors must be retained such as in a spreadsheet form. Thresholds for the screening criteria shall be tailored to the project to ensure that a reasonable number of hours pass the screens. This could include lowering PM10 screens to 50 $\mu g/m^3$ and/or sand flux to 0.1 g/cm^2-hr. The following suggestions for screening criteria are based on those applied in previous successful studies:[1,2,4]

1. Wind speed is greater than 5 m/s (11 miles per hour) at 10-m anemometer height.
2. Hourly modeled and monitored PM_{10} concentrations were both greater than 150 $\mu g/m^3$.
3. Hourly wind direction was within 15 degrees of the direction of the sand flux site to the downwind monitor.
4. Hourly sand flux is greater than 0.5 g/cm^2-hr.

Step 3: Seasonal K-factors can be generated from screened hourly K-factors by looking for shifts in K-factor values. The use of seasonal K-factors provides a longer-term stable value that helps to compensate for uncertainty in hourly K-factors associated with sand flux estimates, dispersion model assumptions, and PM_{10} monitor measurements. It is recommend that seasonal K-factors be based on the geometric mean value of K-factors during each period, and that there be 9 or more hourly values in a seasonal period. This value will provide good seasonal estimates of median PM emissions. For regulatory purposes, the 75-percentile seasonal K-factor has been used to estimate the potential PM emissions for dust control purposes.[4]

Spatial K-factors may be appropriate for different dust source areas within the modeling domain. Differences in soil texture (e.g. sand versus clay soils) or surface conditions can be related to different K-factor ranges. If the monitoring network is set up to monitor multiple surface variations, K-factors can be calculated for each area. Setting up the monitoring network to isolate K-factors from different areas requires good planning to identify downwind monitor locations for each source area. Both spatial and temporal K-factors have been successfully calculated in previous studies at Owens Lake, CA.[1,4]

10.6. *Calculate PM Emissions*. Calculate hourly PM emissions from each source area by applying seasonal K-factors to Equation 1 shown by Equation 4 as follows:

$$F_{i,c} = K_{f,t} \times q_{i,c} \quad (4)$$

where,

$F_{i,c}$ = vertical PM flux for hour i at CSC site c [g/cm^2-hr]
$K_{f,t}$ = geometric mean K-factor for seasonal period t [dimensionless]
$q_{i,c}$ = sand flux (at 15 cm height) for hour i at CSC site c [g/cm^2-hr]

The PM emission flux estimate from Equation 4 is then multiplied by the surface area size of source area c [cm^2] to estimate the total PM emissions for each hour.

11.0 Other Useful Results

11.1. *Method Performance.* Due to the lack of a better measurement method for estimating PM emissions from windblown dust, there is no way to ascertain the true precision and bias of PM emission measurements using this method. However, a comparison of model predictions and observed PM monitor concentrations can provide a relative sense of how well predicted emissions correspond with changes in monitored concentrations, and how much confidence can be given to model predictions at other receptor locations. To determine the model impacts with the seasonal K-factors applied to Equation 4, it is not necessary to re-run the dispersion model. Model results can be re-calculated using the relationship in Equation 2 to relate the initial and seasonal K-factor to the initial and revised model results shown by Equation 5 as follows:

$$C_j' = C_{m,j}\left(\frac{K_{f,t}}{K_i}\right) + C_{b,j} \quad (5)$$

where,

C_j' = Revised hourly PM concentration for hour j [µg/m^3]
$C_{m,j}$ = Initial model-predicted PM concentration for hour j [µg/m^3]
$K_{f,t}$ = geometric mean K-factor for seasonal period t [dimensionless]
K_i = initial K-factor (5×10^{-5}) [dimensionless]
$C_{b,j}$ = Background PM monitor concentration for hour j [µg/m^3]

The revised hourly PM concentrations from Equation 5 can be compared to the hourly monitored concentrations for the same periods. These results can then be compared statistically to evaluate model performance. To avoid misleading model performance results, hourly monitor and model pairs for statistical analyses should be screened to only compare the hours when the monitor is downwind from the dust source areas.

11.2. *Hourly, Daily and Annual PM Emissions.* Daily and annual PM emissions can be summarized from the hourly estimates using Equation 4. When windblown dust is the dominant source of PM at the downwind monitor site, hourly and daily PM emissions and concentrations should be highly correlated.

12.0 Sample Application

The method used in this document was used to quantify windblown dust emissions at Mono Lake, California.[2] A network of 25 CSCs and two Sensits were used to measure sand flux in a 2 km^2 study area. A TEOM measured hourly PM_{10} concentrations on the downwind side of the sand flux network. A satellite photo of the study area and the monitoring network is shown in Figure 6. Boundaries for the source areas were based on soil texture in each area and topographical features on the playa.

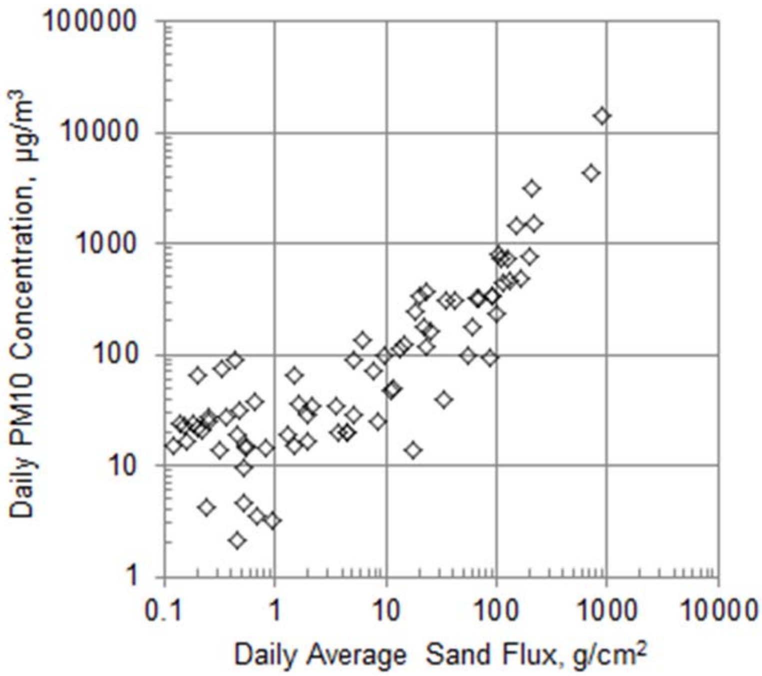


Figure 8. Daily average sand flux from the study area at Mono Lake was linearly related to PM_{10} concentrations at the downwind monitor site (July 2009-June 2010).

The relationship of daily sand flux in the study area to PM_{10} concentrations at the nearby monitor site were linearly related as shown by the log-log plot in Figure 8 (slope=11.1, R^2=0.82). Data were collected from July 2009 through June 2010. The linear relationship between sand flux and PM_{10} supports the theory that PM emissions are proportional to sand flux. In terms of potential PM_{10} impacts, average daily sand flux of around 25 g/cm^2-day measured at 15 cm above the surface corresponded to daily PM_{10} concentrations of around 150 µg/m^3.

Hourly K-factors were calculated using Equation 2 and screened using the criteria described in Section 10.5 to ensure a strong source-receptor relationship. Hourly K-factors are plotted versus time in Figure 9. Several seasonal K-factor cut-points were selected based on shifts observed in K-factor values. The geometric mean K-factor values ranged from 1.3 x 10^{-5} to 5.1 x 10^{-5}. Note that the lack of K-factors from December through March was associated with a period when sand flux was zero because the surface was in a non-erodible condition as a result of either snow cover or moist soil.

Seasonal K-factors were applied to the hourly sand flux to calculate hourly PM_{10} emissions using Equation 4. Hourly PM_{10} emissions are plotted as a function of wind speed as shown on the log-log plot in Figure 10. The Mono Lake wind tunnel PM_{10} emissions algorithm that was originally used to model PM_{10} at Mono Lake is plotted on the same graph to show the contrast between assuming windblown dust emissions as a simple function of wind speed and the scatter in actual emissions versus wind speed.[8] The Mono Lake portable wind tunnel PM_{10} emissions algorithm that was originally used to model PM_{10} at Mono Lake underestimated monitored impacts for large events at this site by about a factor of 7.[9] The use of the sand flux-based hourly emission rates significantly improved model predictions. It should be noted that wind tunnel emission algorithms are normally derived from a limited number of tests. In this

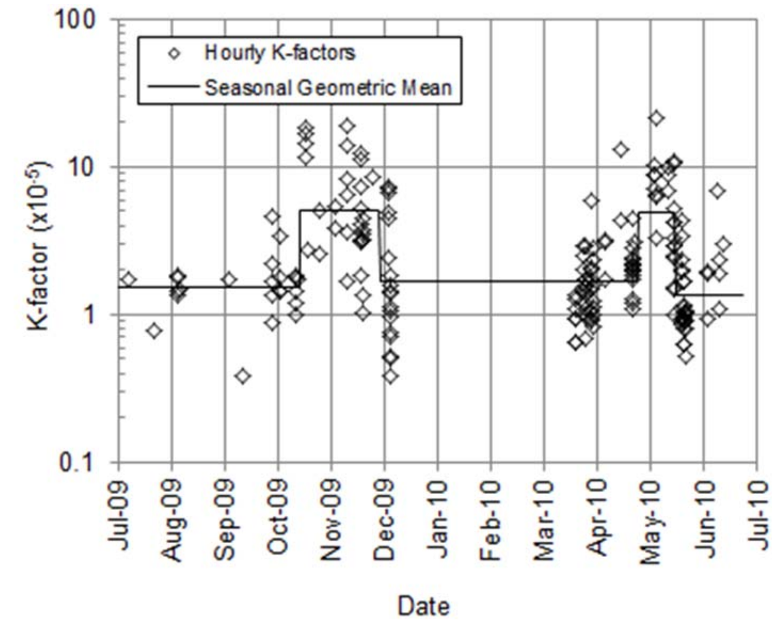


Figure 9. Seasonal shifts in the hourly K-factors at Mono Lake, CA were believed to be caused by changes in surface conditions that affected wind erosion.

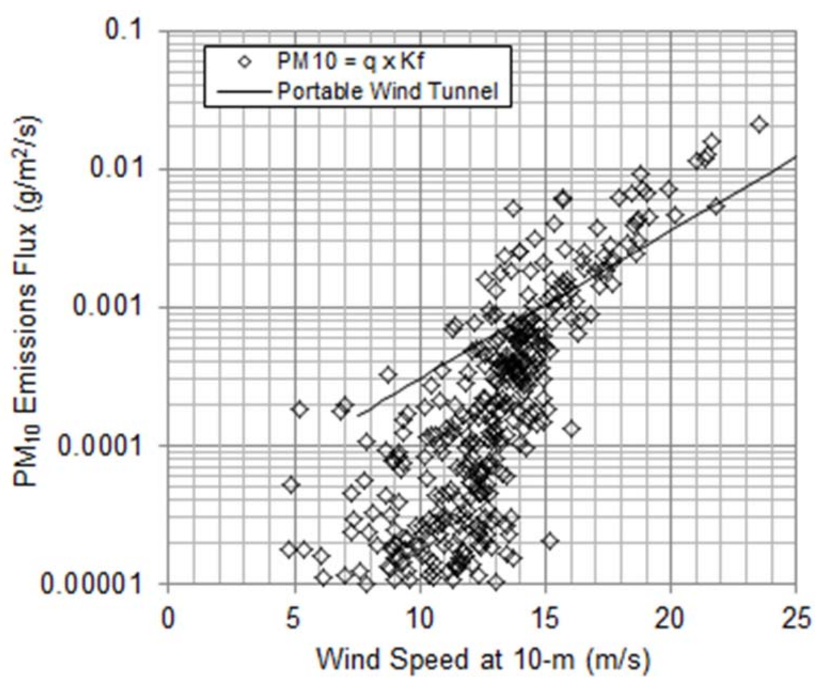


Figure 10. Hourly PM_{10} emission rates using the windblown dust test method were often quite different from those predicted from wind tunnel tests at Mono Lake, CA.

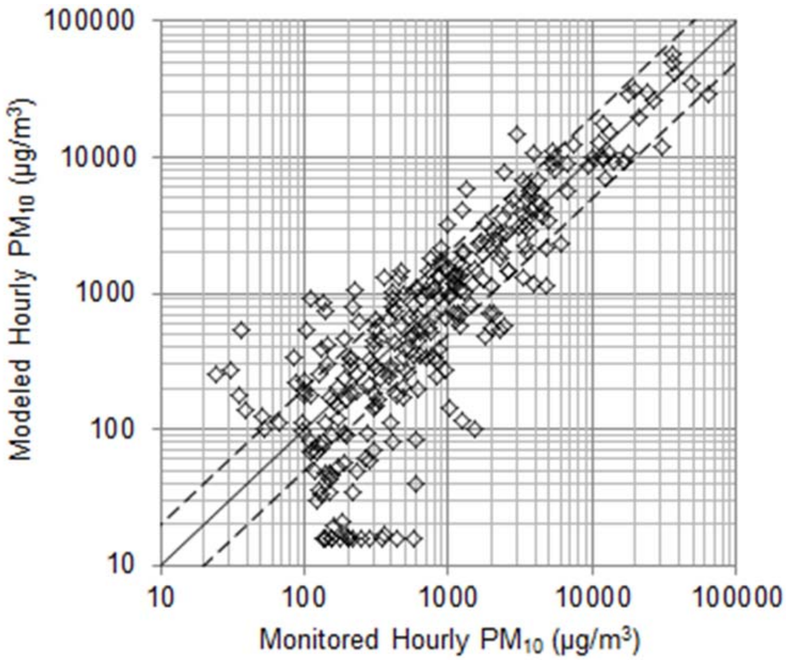


Figure 11. Modeled PM_{10} compared to monitored PM_{10} at Mono Lake. The dashed lines are a factor of two above and below the one to one line.

case, there were only 6 data points to derive the wind tunnel algorithm,[10] as compared to the 355 hourly data points for the windblown dust test method shown in Figure 10. This semi-log plot does not show hours with zero emissions for which there were 8,020 hours during the one-year study period.

A comparison of hourly model concentrations to downwind PM_{10} monitor concentrations is shown by the log-log plot in Figure 11. Sixty percent of the hourly model concentrations were within a factor of 2 above or below the PM_{10} monitor concentrations as indicated by the dashed lines. Statistically, the model prediction versus monitor concentration comparison had a slope of 0.89 and the R^2 was 0.77. Figure 12 shows that the model-predicted PM_{10} concentrations tracked favorably with the monitor concentrations over a 4-order of magnitude range for the largest dust event during the study period on November 20, 2009. The 24-hour average concentration for this event was 14,147 µg/m^3 and the model-predicted concentration was 16,062 µg/m^3. The maximum hourly PM_{10} emission rate for this event was 76 g/m^2-hr, which occurred with an hourly average wind speed of 23.5 m/s (53 miles per hour). Maximum daily PM_{10} emissions were 450 g/m^2-day on November 20, 2009. For the one year study period the annual emission rate was estimated to be 1,095 g/m^2-yr.

13.0 BSNEs and Other Sand Flux Instruments

The methodology described in this document recommends the use of CSCs to measure sand flux. Other types of sand flux measurement instruments have been used by wind erosion researchers. One common type that has been used by the US Department of Agriculture and others for wind erosion studies is the BSNE manufactured by Custom Products in Big Springs, TX. BSNEs have wind vanes to point the inlets into the wind. They are often placed at multiple heights above the surface to measure total sand flux, which is the mass of sand-sized particles

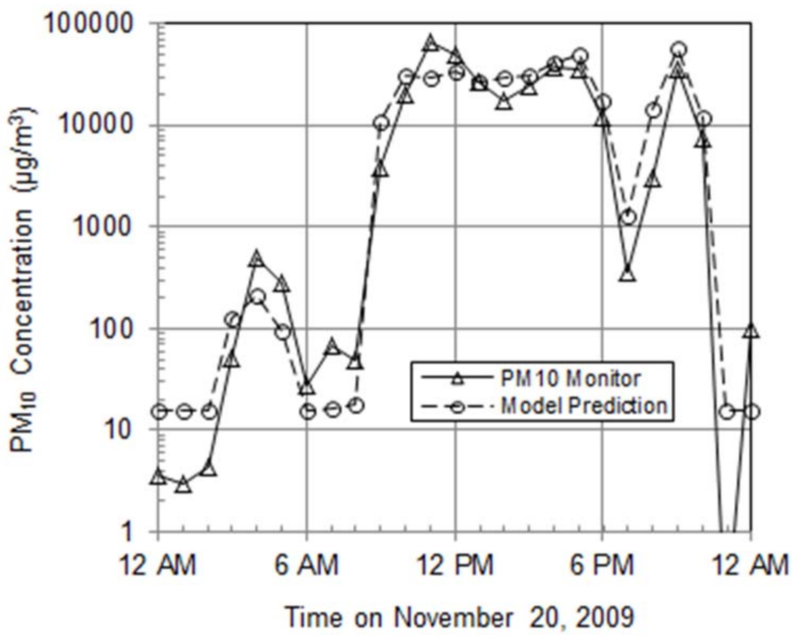


Figure 12. PM_{10} model predictions using the windblown dust test method tracked favorably with monitor concentrations over a 4-order magnitude range as shown for this dust event on November 20, 2009 at Mono Lake, CA.

passing perpendicular through a vertical plane of given width and infinite height [mass/length]. Total sand flux can be calculated by measuring sand flux at multiple heights, fitting the data to a mathematical curve[1,11] and then integrating from 0 to 1 m, which is the region where most of the saltation flux occurs. For relatively flat terrain, the flux at a given height is proportional to the total sand flux. The proportion of sand flux at 15 cm can be determined by integrating the sand flux from 14.5 to 15.5 cm and comparing it to the total sand flux. Long-term measurements using multi-height BSNE samplers at Owens Lake[1] found that the relationship of the total sand flux, Q to the sand flux at 15 cm (q_{15}) was

$$\frac{Q}{q_{15}} = 42\ [\mathrm{cm}] = 0.42\ [\mathrm{m}] \qquad (6)$$

This same relationship was confirmed by another study in a coastal dune area in California.[12] It should be noted that the BSNE has a smaller storage volume than CSCs and that daily site visits may be needed to avoid overloading the BSNE samplers in areas with high erosion activity.

14.0 Using Sand Flux Measurements as a Survey Tool

14.1. *Survey Tool and Control Measure Evaluation*. Sand flux measurements can provide useful information by themselves, even if PM_{10} monitor data or modeling information is not available. Sampling with CSCs can identify areas that are susceptible to wind erosion. With multiple sample sites collecting data, a relative gage of wind erosion in each area can be ascertained. This type of information can be useful when evaluating the effectiveness of dust control measures.

14.2. *Estimating PM Emissions with Sand Flux*. If K-factors are available for a soil type, sand flux data can be used to estimate PM dust emissions for a given sampling period. For loose sandy soils, such as those found in sand dunes a K-factor range of 1.3×10^{-5} to 5.1×10^{-5} was measured from the exposed playa at Mono Lake, California in the example provided in Section 12.0. A similar range of K-factors has been measured for sandy playa soils and sand dunes at Owens Lake, California.[1,2,4] These sites are more than 100 miles apart and in different hydrologic basins, but have similar K-factor ranges. As more soil types are tested using this method other K-factor ranges may be determined. However, it should be noted that better PM emission quantification requires upwind and downwind monitoring of PM to determine K-factors specific for the source area of interest. Once a K-factor range is determined for the soil type and conditions of interest, default K-factors based on that range could be used with sand flux data to estimate PM emissions.

14.3. *Wind Erosion Threshold*. Combining Sensits with CSCs allows the user to time-resolve sand flux. Hourly sand flux and wind speed data can be analyzed to determine the threshold wind speed, which is the wind speed that initiates wind erosion.[12,13] If collected, 5 minute wind speed data can be used with the 5-minute sand flux data to give a more refined threshold determination. Threshold wind speed information is helpful for control measure evaluation and for identifying situations where exceptionally high wind speeds may cause dust control measures to lose their effectiveness.

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Appendix A
List of Required Measurements to Quantify PM Emissions from Windblown Dust

Measurement Parameter	Equipment	Required at test site?
Hourly Average Particulate Matter	TEOM, BAM or other Federal Equivalent Method PM monitors capable of measuring hourly PM_{10} or $PM_{2.5}$ concentrations at upwind and downwind locations. The upwind PM monitor may be located at a local site representative of conditions upwind from the test area during wind event periods.	Yes
Hourly Average Scalar Wind Speed	Anemometer positioned at 5 to 10 meters above the surface.	Yes
Hourly Average Scalar Wind Direction	Wind vane positioned at 5 to 10 meters above the surface.	Yes
Sigma Theta ($\sigma\theta$)	Standard deviation of azimuth angle of wind direction.	Yes
Precipitation	Rain gauge (optional measurement)	No
Ambient Temperature	Thermistor (local data may be used)	No
Barometric Pressure	Aneroid Barometer (local data may be used)	No
Relative Humidity	Psychrometer/hygrometer (local data may be used)	No
Solar Radiation	Pyranometer (local data may be used)	No
Cloud Cover	Visual observation (local data may be used)	No
Hourly Average Sand Flux	Cox Sand Catchers or BSNEs with Sensits at one or more sites to time-resolve sand catch mass to estimate hourly sand flux at each location. A lab balance capable of measuring to ±0.1 g will be needed to determine sand catch mass.	Yes

Data loggers will be needed to record meteorological and Sensit data. Additional data loggers may be used to back-up the internal data storage devices on the PM monitors. Power supplies for the meteorological tower and Sensit can be provided by solar power systems. PM monitors will likely need line power to provide sufficient power to operate continuously.

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Appendix B
Measurement Quality Objectives Validation Template

Measurement Quality Objectives (MQOs) for all $PM_{2.5}$ and PM_{10} monitoring conducted for this method should follow the guidance provided by the USEPA for measuring ambient PM concentrations using Federal Equivalent Method monitors. As discussed in the method description and listed in Appendix A, some meteorological measurements are not required, but MQOs are included in this appendix to provide complete information for the user.

Continuous $PM_{2.5}$ Local Conditions Validation Template[14]

Criteria	Frequency	Acceptable	Information (CFR or QA Guidance 2.12[18])
Sampling Period			
24 hour estimate	every sample period	1380-1500 minutes, or value if < 1380 and exceedance of NAAQS [1/] midnight to midnight	40 CFR Part 50 App. L, Sec 3.3 40 CFR Part 50, App. L, Sec 7.4.15
Hour estimate	Every hour	Instrument dependent	See operators manual
Sampling Instrument			
Average Flow Rate	every 24 hours of op	average within 5% of 16.67 liters/minute	40 CFR Part 50 App. L, Sec 7.4
Variability in Flow Rate	every 24 hours of op	CV $\leq$ 2%	40 CFR Part 50, App. L, Sec 7.4.3.2
Verification/Calibration			
One-point Flow Rate Verification	1/4 weeks	± 4% of transfer standard	40 CFR Part 50, App. L, Sec 9.2.5 40 CFR Part 58, App. A, Sec 3.2.3 & 3.3.2
Reference Membrane Verification (BAM)	Hourly	± 4% of ABS Value	
Verification/Calibration			
Leak Check	every 30 days	Instrument dependent	40 CFR Part 50, App. L, Sec 7.4
Temperature Calibration	if multi-point failure	± 2 °C	40 CFR Part 50, App. L, Sec 9.3
Temp M-point Verification	on installation, then 1/yr	± 2 °C	40 CFR Part 50, App. L, Sec 9.3
One-point Temp Check	1/4 weeks	± 2 °C	40 CFR Part 50, App. L, Sec 9.3
Pressure Calibration	on installation, then 1/yr	± 10 mm Hg	40 CFR Part 50, App. L, Sec 9.3
Pressure Verification	1/4 weeks	± 10 mm Hg	40 CFR Part 50, App. L, Sec 9.3
Other Monitor Calibrations	per manufacturers' op manual	per manufacturers' operating manual	
Flow Rate (FR) Calibration	if multi-point verification	± 2%	40 CFR Part 50, App. L, Sec 9.2
FR Multi-point Verification	1/yr	± 2%	40 CFR Part 50, App. L, Sec 9.2
Design Flow Rate Adjustment	at one-point or multi-point	± 2% of design flow rate	40 CFR Part 50, App. L, Sec 9.2.6
Precision			
Collocated Samples	every 12 days for 15% of sites	CV $\leq$ 10% of samples > 3 $\mu g/m^3$	40 CFRPart 58 App. A Sec 3.2.5

Criteria	Frequency	Acceptable Range	Information (CFR or QA Guidance 2.12[18])
Accuracy			
Temperature Audit	2/yr	± 2 °C	QA Guidance Document 2.12, Sec 10.2
Pressure Audit	2/yr	±10 mm Hg	QA Guidance Document 2.12, Sec 10.2
Semi Annual Flow Rate Audit	2/yr	± 4% of audit standard ± 5% of design flow rate	QA Guidance Document 2.12, Sec 10.2
Calibration & Check Standards (working standards)			40 CFR Part 58, App. A, Sec 3.3.3
Field Thermometer	1/yr	± 0.1 °C resolution, ± 0.5 °C accuracy	QA Guidance Document 2.12, Sec 4.2 & 6.4
Field Barometer	1/yr	± 1 mm Hg resolution, ± 5 mm Hg accuracy	QA Guidance Document 2.12, Sec 4.2 & 6.5
Shelter Temperature			
Temperature range	**Daily** (hourly values)	20 to 30 °C (hourly average), or per manufacturers' specifications if designated to a wider temperature range	Generally the 20-30 °C range will apply but the most restrictive operable range of the instruments in the shelter may also be used as guidance
Temperature Control	Daily (hourly values)	± 2 °C SD over 24 hours	
Temperature Device Check	2/year	± 2 °C	
Monitor Maintenance			
Virtual Impactor Very Sharp Cut Cyclone	Every 30 days	cleaned/changed	QA Guidance Document 2.12, Sec 9.2
Inlet Cleaning	Every 30 days	cleaned	QA Guidance Document 2.12, Sec 9.3
Filter Chamber Cleaning	1/4 weeks	cleaned	QA Guidance Document 2.12, Sec 9.3
Circulating Fan Filter Cleaning	1/4 weeks	cleaned/changed	QA Guidance Document 2.12, Sec 9.3
Manufacturer-Recommended Maintenance	per manufacturers' SOP	per manufacturers' SOP	
SYSTEMATIC CRITERIA- $PM_{2.5}$ Continuous, Local Conditions			
Data Completeness	monthly	≥ 90%	Part 50, App. N, Sec. 4.1 (b) 4.2 (a)
Reporting Units		μg/m^3 at ambient temp/pressure ($PM_{2.5}$)	40 CFR Part 50.3
Rounding Convention			
Annual 3-yr average	quarterly	nearest 0.1 μg/m^3 (≥0.05 round up)	40 CFR, Part 50, App. N, Sec 2.3
24-hour, 3-year average	quarterly	nearest 1 μg/m^3 (≥0.5 round up)	40 CFR Part 50, App. N, Sec 2.3
Detection Limit			
Lower DL	all filters	≤ 2 μg/m^3	40 CFR Part 50, App. L ,Sec 3.1
Upper Conc. Limit	all filters	≥ 200 μg/m^3	40 CFR Part 50, App. L, Sec 3.2

Criteria	Frequency	Acceptable Range	Information (CFR or QA Guidance 2.12[18])
VERIFICATION/CALIBRATION STANDARDS RECERTIFICATION - All standards should have multi-point certifications against NIST Traceable standards			
Flow Rate Transfer Std.	1/yr	± 2% of NIST-traceable Std.	40 CFR Part 50, App. L, Sec 9.1 & 9.2
Field Thermometer	1/yr	± 0.1 °C resolution, ± 0.5 °C accuracy	QA Guidance Document 2.12, Sec 4.2.2
Field Barometer	1/yr	± 1 mm Hg resolution, ± 5 mm Hg accuracy	QA Guidance Document 2.12, Sec 4.2.2
Calibration & Check Standards			
Flow Rate Transfer Std.	1/yr	± 2% of NIST-traceable Std.	40 CFR Part 50, App. L, Sec 9.1 & 9.2
Verification/Calibration Clock/timer Verification	1/4 weeks	1 min/mo**	40 CFR Part 50, App. L, Sec 7.4
Precision			
Single analyzer	1/3 mo.	Coefficient of variation (CV) $\leq$ 10%	
Single analyzer	1/ yr	CV $\leq$ 10%	
Primary Quality Assurance Org.	Annual and 3 year estimates	90% CL of CV $\leq$ 10%	40 CFR Part 58, App. A, Sec 4.3.1
Bias			
Performance Evaluation Program (PEP)	8 audits for > 5 sites	±10%	40 CFR Part 58, App. A Sec 3.2.7, 4.3.2

1/ = value must be flagged due to current implementation of BAM (sampling 42 minute/hour) only 1008 minutes of sampling in 24 hour period
*** = not defined in CFR**
SD = standard deviation
CV = coefficient of variation
@ = scheduled to occur immediately after impactor cleaned/changed
**** = need to ensure data system stamps appropriate time period with reported sample value**

Continuous PM_{10} Standard Temperature and Pressure Conditions Validation Template[14]

NOTE: There are a number of continuous PM_{10} monitors that are designated as Federal Equivalent Monitors. These monitors may have different measurement or sampling attributes that are not identified in this validation template. Monitoring organizations should review specific instrument operating manuals to augment this validation template as necessary. In general, 40 CFR Part 58 App. A and 40 CFR part 50 App. J requirements apply to Continuous PM_{10}. Since a guidance document was never developed for continuous PM_{10}, many of the requirements reflect a combination of manual and continuous $PM_{2.5}$ requirements and are therefore considered recommendations.

Criteria	Frequency	Acceptable Range	Information (CFR or QA Guidance 2.12[18])
CRITICAL CRITERIA- PM_{10} Continuous			
Sampling Period	all filters	1380-1500 minutes, or value if < 1380 and exceedance of NAAQS [1/] midnight to midnight	40 CFR Part 50 App. J, Sec 7.1.5
Sampling Instrument			
Average Flow Rate	every 24 hours of operation	Average within ± 10% of design	recommendation
Verification/Calibration One-point Flow Rate Verification	1/mo	± 5% of transfer standard and 10% from design	40 CFR Part 58, App. A, Sec 3.2.3
OPERATIONAL EVALUATIONS TABLE PM_{10} Continuous			
Verification/Calibration			
System Leak Check	During pre-calibration check	Instrument dependent	QA Guidance Document 2.12, Sec 6.62
FR Multi-point Verification/Calibration	1/yr	3 of 4 cal points within ± 10% of design	QA Guidance Document 2.12, Sec 6.3.4
Audits			
Quarterly Flow Rate Audit	1/3 mo	± 5% of audit standard and ±10% of design value	40 CFR Part 58, App. A, Sec 3.2.4
Monitor Maintenance			
Inlet/downtube Cleaning	1/mo. minimum	cleaned	QA Guidance Document 2.12, Sec 9.3 & 9.4
Pump Replacement	1/18 mos. maximum	Inspected, replaced	per manufacturers' SOP, increase as needed
Inline Filter, Inlet Seal Replacement	Inspect 1/mo., Repl. 1/6 mos.	Replace semi-annually (1/6 mos.)	QA Guidance Document 2.12, Sec 9.4, 9.5 & 9.6
Manufacturer-Recommended Maintenance	per manufacturers' SOP, increase as needed	per manufacturers' SOP, increase as needed	
SYSTEMATIC CRITERIA – PM_{10} Continuous			
Data Completeness	monthly	≥ 90%	40 CFR Part 50 App. K, Sec. 2.3
Reporting Units	Hourly concentrations, $\mu g/m^3$	$\mu g/m^3$ at standard temperature and pressure (STP)	40 CFR Part 50 App. K

Criteria	Frequency	Acceptable Range	Information (CFR or QA Guidance 2.12[18])
Rounding Convention			
24-hour average	daily	nearest 1 μg/m^3 ($\geq$ 0.5 round up)	40 CFR Part 50 App. K sec 1
Verification/Calibration Standards and Recertifications - All standards should have multi-point certifications against NIST Traceable standards			
Flow Rate Transfer Std.	1/yr	± 2% of NIST-traceable Std.	40 CFR Part 50, App. J sec 7.3
Field Thermometer	1/yr	± 0.1 °C resolution, ± 0.5 °C accuracy	recommendation
Field Barometer	1/yr	± 1 mm Hg resolution, ± 5 mm Hg accuracy	recommendation
Calibration & Check Standards			
Flow Rate Transfer Std.	1/yr	± 2% of NIST-traceable Std.	QA Guidance Document 2.12, Sec 6.3.2
Verification/Calibration			
Clock/timer Verification	4/year	5 min/mo	recommendation

CRITICAL CRITERIA TABLE - METEOROLOGICAL MEASUREMENT METHODS

S - single instrument hourly value, G - group of hourly values from 1 instrument

Parameter	Criteria	Acceptable Range							Frequency	Samples Impacted	EPA-454/ R-99-005 Feb 2000	EPA Regulation & Guidance	ADEC AM&QA QAPP
	Method	**Measurement Method Characteristics**											
		Reporting Units	**Range**	**Accuracy**	**Resolution**	**Starting Speed**	**Distance Constant**	**Sampling Frequency**	**Raw Data Collection Frequency**				
Wind Speed (WS)	Cup, blade, or heated sonic anemometer	m/s	0.5 m/s - 50 m/s	± 0.2 m/s	0.25 m/s	≤ 0.5 m/s	≤ 0.5 m @ 1.2 kg/m³	hourly	1 minute	All Data	Ch 2 Sec 1 &8, Ch 5 Sec 1 & 2, Ch 8 Sec 1	QA Handbook Vol IV Sec 0 Tables 0-3, 0-4, 0-5, 0-6	Section 7 Table A8
Vertical WS (VWS)			-25 m/s - +25 m/s	± 0.2 m/s	0.1 m/s	≤ 0.25 m/s	≤ 0.5 m @ 1.2 kg/m³	hourly	1 minute	All Data			
							Damping Ratio						Delay Distance
WD (azimuth & elevation)	Vane or heated Sonic anemometer	Degrees (°)	1°-360° or 540°	± 5 degrees	1.0 degree	≤ 0.5 m/s @ 10 degrees	0.4 to 0.7 @ 1.2 kg/m³	hourly	1 minute	All Data			≤ 0.5 m @ 1.2 kg/m³
						Time Constant	**Spectral Response**						
Ambient Temp	Thermistor 10m - 2m	Degrees Celsius (°C)	-40°C to +40°C	± 0.5°C	0.1°C	≤ 1 minute		hourly	1 minute	All Data	Ch 2 Sec 3 &8, Ch 3 Sec 6, Ch 5 Sec 1&2, Ch 8 Sec 1		Section 7 Table A8
Vertical Temp Difference (ΔT)			-40°C - +40°C	± 0.1°C	0.02°C	1 minute		hourly	1 minute	All Data			
Dew Point Temperature	Psychrometer/ Hygrometer %	°C	-40°C - +40°C	± 1.5°C	0.1°C	30 minutes		hourly	1 minute	All Data	Ch 2 Sec 4&8, Ch 5 Sec 1&2		
Relative Humidity/		%	0 to 100%	± 7%	0.5 %	≤ 30 minutes		hourly	1 minute	All Data			
Barometric Pressure (BP)	Aneroid Barometer	mb	600 mb - 1050 mb Hg	± 3 mb Hg (0.3 kPa)	0.5 mb Hg			hourly	1 minute	All Data	Ch 2 Sec 6 &8, Ch 5 Sec 1&2		

ADEC – Alaska Department of Environmental Conservation
AM&QA QAPP – Air Monitoring and Quality Assurance QAPP (used by the USEPA to develop the MQO tables for meteorological measurements for Vol. IV guidance document)

CRITICAL CRITERIA TABLE - METEOROLOGICAL MEASUREMENT METHODS S - single instrument hourly value, G - group of hourly values from 1 instrument													
Parameter	**Criteria**	**Acceptable Range**							**Frequency**	**Samples Impacted**	**EPA-454/ R-99-005 Feb 2000**	**EPA Regulation & Guidance**	**ADEC AM&QA QAPP**
Solar Radiation	Pyranometer	Watts/m^2	0 - 1300	± 5% of observed	10 W/m^2	5 seconds	285 nm to 2800 nm	hourly	1 minute	All Data	Ch 2 Sec 7 &8, Ch 5 Sec 1&2		
Precipitation	Tipping Bucket (with Alter type windscreen & heater)	mm H20	0 - 50 mm H_2O/hr	± 10% of observed or ± 0.5	0.3 mm H_2O			hourly	1 minute	All Data	Ch 2 Sec 5 &8, Ch 5 Sec 1&2		
	Method	**Measurement Method Characteristics (continued)**											
		Reportin g Units	**Range**	**Accuracy**	**Resolution**			**Sampling Frequency**	**Raw Data Collection Frequency**				
Vector Data WS	DAS Calculation	m/s	- 50.0 m/s	± 0.2 m/s	0.1 m/s			hourly	1 minute	All Data	Ch 4 Sec 6, Ch 8		
Vector Data WD	DAS Calculation	Degrees (°)	0 - 360°	± 5°	1.0°			hourly	1 minute	All Data	Ch 4 Sec 6, Ch 8	QA Handbook Vol IV Sec 0 Tables 0-3, 0-4, 0-5, 0-6	
sigma theta (σθ)	DAS Calculation SD of azimuth angle of WD	Degrees (°)	0 - 105°	± 5°	1.0°			hourly	15 minute	All Data	Ch 4 Sec 6, Ch 8		Sec 7 Table A8
sigma phi (σw)	DAS Calculation SD of vertical component of WS	m/s	0 - 10 m/s	± 0.2 m/s	0.1 m/s			hourly	1 minute	All Data	Ch 4 Sec 6, Ch 8		Sec7 Table A8
		Radiation Range	**Flow Rate**	**Radiation Error**	**Type**	**Estimates of Means**		**Estimates of Variance**					
Motor aspirated temp radiation shield (T, ΔT, RH/Dew Point)		-100 - 1300 W/m^2	3 m/s	< 0.2°C							Ch 2 Sec 3 &4, Ch 8 Sec 1		
Data Acquisition System (DAS)					Micro processor-based digital	1/min for hourly mean (60 samples/hour)		6 samples/min for hourly variance (360 samples/hour)			Ch 4 Sec 6, Ch 8		

CRITICAL CRITERIA TABLE - METEOROLOGICAL MEASUREMENT METHODS

S - single instrument hourly value, G - group of hourly values from 1 instrument

	Reporting Intervals						
Parameter	**Criteria**	**Acceptable Range**	**Frequency**	**Samples Impacted**	**EPA-454/ R-99-005 Feb 2000**	**EPA Regulation & Guidance**	**ADEC AM&QA QAPP**
All parameters	Hourly average		Quarterly	All	Ch 5 Sec 1		Sec 7
	Data Completeness						
All parameters	Valid data capture	≥75 %	Hourly	G	Ch 5 Sec 3 & 4	QA Handbook Vol IV Sec 0 Tables 0-3, 0-4, 0-5, 0-6	Sec 7 18 AAC 50.010
	(PSD Quality Monitoring) Valid data capture	≥90% hourly data, joint collection of WS, WD, and stability (σθ or σφ depending upon model selection)	Quarterly (4 consecutive quarters)	G			
	Calibration						
WS, VWS	**Multi-point Calibration**	5 points including zero, 2 m/s and 3 additional evenly spaced upscale points covering expected wind speeds for the site All test points ≤ ± **(2 m/s + 5% of observed)** WS bearing torque threshold ≤ **PSD quality sensor manufacturer's specs**	Initially, 1/6 months thereafter	G	Ch 5	QA Handbook Vol IV All Sections and 0 Tables 0-3, 0-4, 0-5, 0-6	Section 7 MQO Table A8
WS/WD Sonic Anemometer	**Multi-point Calibration**	Multipoint calibration via wind tunnel by manufacturer	Initially, 1/year thereafter				
WD, VWD	**Multi-point Calibration**	Alignment to True North + linearity test points at: 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°, 360° Alignment ≤ **±5°** Linearity (All Points) ≤ ± **3° (included in ≤ ± 5° above)** WD bearing torque threshold ≤ **PSD quality sensor manufacturer's specs**	Initially, 1/6 months thereafter	G	Ch 5 Ch 8		

CRITICAL CRITERIA TABLE - METEOROLOGICAL MEASUREMENT METHODS

S - single instrument hourly value, G - group of hourly values from 1 instrument

Parameter	Criteria	Acceptable Range	Frequency	Samples Impacted	EPA-454/ R-99-005 Feb 2000	EPA Regulation & Guidance	ADEC AM&QA QAPP
Temp	**Multi-point Calibration**	Minimum 3 point calibration representative of min avg low to max avg high temps for the location. (e.g., -30°C, 0°C, +30°C) Each point **≤±0.5°C** of NIST Traceable Standard	Initially, 1/6 months thereafter	G	Ch 5 Ch 8		MQO Table, Table A8 Sec 16
ΔT	**Multi-point Calibration**	Side-by-side calibration of 10m and 2m temp probes with a Minimum 3 point calibration representative of min avg low to max avg high temps for the location. (e.g., -30°C, 0°C, +30°C) Each point **≤±0.5°C** of NIST Traceable Standard and 10m sensor **≤±0.1°C** of 2 m sensor at all points	Initially, 1/6 months thereafter	G	Ch 5 Ch 8		MQO Table, Table A8 Sec 16
RH/Dew point	**Multi-point Calibration**	Factory multi-point calibration followed by on-site 1-point verification of RH/DP sensor against NIST Traceable RH Standard (±2% RH accuracy) RH sensor **≤ ± 7% of RH Standard**	Initially, 1/6 months thereafter	G	Ch 5 Ch 8		MQO Table, Table A8 Sec 16
Solar Radiation (SR)	**Multi-point Calibration**	Factory multi-point calibration followed by on-site zero check with opaque cover 1-point verification against in-cert. First Class collocated Pyranometer SR sensor **≤ ± 5% of First Class Pyranometer**	Initially, 1/6 months thereafter	G	Ch 5 Ch 8		MQO Table, Table A8 Sec 16
Barometric Pressure (BP)	**Multi-point Calibration**	Factory multi-point calibration followed by on-site 1-point verification against pressure standard of known quality (see pressure std. min requirements) BP sensor **≤ ± 3 mb (0.3 kPa)**	Initially, 1/6 months thereafter	G	Ch 5 Ch 8		MQO Table, Table A8 Sec 16
Precipitation	**Multi-point Calibration**	Minimum 3 point calibration Each point ”± 10% of measured H_2O input, or **≤ ± 5 mm H_2O**	Initially, 1/6 months thereafter	G	Ch 5 Ch 8	QA Handbook Vol IV Sec 4 and Sec 0 Tables 0-3, 0-4, 0-5, 0-6	MQO Table, Table A8 Sec 16
Vector Data/DAS (WS, WD, σΘ, σw)	**Multi-point Calibration**	Calibrate/check DAS voltage input against sensor inputs **WS, σw ≤ ± 0.2 m/s** **WD ≤ ± 5°**	Initially, 1/6 months thereafter	G	Ch 5 Ch 8	QA Handbook Vol IV Sec 9 and Sec 0 Tables 0-3, 0-4, 0-5, 0-6	

OPERATIONAL EVALUATIONS TABLE - METEOROLOGICAL MEASUREMENT

S - single instrument hourly value, G - group of hourly values from 1 instrument

Parameter	Criteria	Acceptance Range	Frequency	Samples Impacted	EPA-454/ R-99-005 Feb 2000	EPA Regulation& Guidance	ADEC AM&QA QAPP
	Siting & Exposure Criteria						
All met parameters	Representativeness	Site must be representative for the intent of the monitoring scale , No prescribed quantitative criteria **See references**	All	All	Ch 3 Sec 1	QA Handbook Vol IV , Section 10-6	
All met parameters	Probe Siting	*See references for specific siting criteria for simple, complex, coastal and urban terrain locations*	All	All	Ch 3 Sec 2&3		
	Calibration/Audit						
WS/ VWS	WS standard Sonic Anemometers calibrated @ factory	NIST Traceable Synchronous motor, or Series of NIST Traceable constant speed motors to generate WS in range of 2 m/s thru 50 m/s	Purchase, recalibrate 1/year or at frequency dependent upon use	G		QA Handbook Vol IV Sec 0 Tables 0-3, 0-4, 0-5, 0-6 Sec 2	Sec 16
WS/WD	Collocated Transfer Standard (CTS) for sonic anemometer audits	CTS must be cup/vane or aerovane anemometer that is calibrated on-site with standards/personnel independent from routine operator/calibration staff and equipment/standards. CTS must meet all PSD quality criteria	Purchase, Calibrate CTS on site prior to conducting each site audit, and CTS collocated for 72 hr minimum	G			
WD/VWD	WD Standard	**Alignment to True North** • Solar Noon method, and or • Transit & Compass, map, and site magnetic declination, or • GPS accuracy $\leq$ 3 meters with lock on minimum 3 satellite signals **Linearity** Linearity wheel with evenly spaced preset markings, e.g., 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°, 360°	Purchase, recalibrate 1/year or at frequency dependent upon use	G			

OPERATIONAL EVALUATIONS TABLE - METEOROLOGICAL MEASUREMENT

S - single instrument hourly value, G - group of hourly values from 1 instrument

Parameter	Criteria	Acceptance Range	Frequency	Samples Impacted	EPA-454/ R-99-005 Feb 2000	EPA Regulation & Guidance	ADEC AM&QA QAPP
Temperature	Thermister	• measurement range -50°C to + 40°C • Accuracy ≤±0.2°C NIST traceable certified over -30°C to +30°C • Resolution ≤±0.1°C	Purchase, recertify 1/year or per NIST/ASTM certification frequency	G		QA Handbook Vol IV Sec 3, & Sec 0 Tables 0-3, 0-4, 0-5, 0-6	
RH/Dew Point	RH meter or Assman Style Psychrometer	**RH meter** NIST Traceable Standard ± 2% RH **Assman Style Psychrometer** with matched pair NIST Traceable/ASTM Thermometers with measurement Resolution 0.1° C each and appropriate temp range **No Sling Psychrometer Acceptable**	Purchase, recertify 1/year or per NIST traceable certification frequency	G		QA Handbook Vol IV , Sec 5 & Sec 0 Tables 0-3, 0-4, 0-5, 0-6	
Solar Radiation	NIST Traceable Pyranometer	**First Class Pyranometer** Measurement range Measurement resolution Measurement accuracy	Purchase, recertify 1/year or per NIST traceable certification frequency	G		QA Handbook Vol IV Sec 6 & Sec 0 Tables 0-3, 0-4, 0-5, 0-6	Sec 16
Barometric Pressure	NIST Traceable Aneroid Barometer	Measurement accuracy ± 1mb, Measurement resolution 0.1 mb, Measurement range 950 - 1050 mb	Purchase, verify 1/year against NWS-FAA or NIST Traceable Std. or per NIST traceable certification frequency	G		QA Handbook Vol IV Sec 7 & Sec 0 Tables 0-3, 0-4, 0-5, 0-6	
Precipitation	Separatory funnel, duated cylinder, and deionized water	**Volumetric Glassware** Calibrated (50ml or 100 ml, 1 ml divisions), and **Deionized H_2O**	Purchase	G		QA Handbook Vol IV Sec 5 & Sec 0 Tables 0-3, 0-4, 0-5, 0-6	
	Visual QC Checks-Field						
	Sky Check	Note & Record sky conditions (cloud cover, temp/WS/WD, etc. estimates)	Each site visit	G		QA Handbook Vol IV	

OPERATIONAL EVALUATIONS TABLE - METEOROLOGICAL MEASUREMENT

S - single instrument hourly value, G - group of hourly values from 1 instrument

Parameter	Criteria	Acceptance Range	Frequency	Samples Impacted	EPA-454/ R-99-005 Feb 2000	EPA Regulation & Guidance	ADEC AM&QA QAPP
WS	WS sensor	Moving freely, no visual damage	Each site visit	G		Sec 10.2	
WD	WD sensor	Moving freely, no visual damage	Each site visit	G			
Temperature, ΔT	Temperature sensors and aspirated temperature shields	No visual damage or obstruction, Motor in aspirated shield working	Each site visit	G			
SR	Solar Radiation Sensor	Radiometer/pyranometer face clear of dirt/debris/snow	Each site visit	G			
BP	Pressure sensor	No visual damage or obstruction	Each site visit	G			
RH	RH sensor, aspirated shield	S	Each site visit	G			
Precipitation	Precipitation sensor	No visual damage or obstruction, free of ice and snow, Heater working	Each site visit	G			
DAS	Data Acquisition System	DAS time ≤ 1 minute NIST Alaska Standard aaTime1	Each site visit	G			
	Data Screening Criteria						
WS/ VWS	Hourly Recorded WS	0 m/s ≥ WS ≤25 m/s0, WS varies ≥0.1 m/s/3 consecutive hours, WS varies ≥ 0.5 m/s/12 consecutive hours, or per site specific climatology criteria	1/week or more frequent	G	Ch 8, Table 8-4	QA Handbook Vol IV Sec 10.4	
WD/VWD	Hourly Recorded WD	0°≥ WD ≤360°, WD varies ≥ 1°/3 consecutive hours, or per site specific climatology criteria	1/week or more frequent	G	Ch 8, Table 8-4		
Temperature	Hourly Recorded Ambient Temperature	Local record low≥ Temp ≤ local record high, Temp ≤ 5°C from previous hourly record, Temp varies ≥ 0.5°C/12 consecutive hours, or per site specific climatology criteria	1/week or more frequent	G	Ch 8, Table 8-4		
10m - 2 m ΔT	Hourly Recorded 10m - 2m Temperature Difference	Day time ΔTemp < 0.1°C/m, Night time ΔTemp > -0.1°C/m, -3.0°C > ΔT < 5.0°C, or Per site specific climatology criteria	1/week or more frequent	G	Ch 8, Table 8-4		

OPERATIONAL EVALUATIONS TABLE - METEOROLOGICAL MEASUREMENT

S - single instrument hourly value, G - group of hourly values from 1 instrument

Parameter	Criteria	Acceptance Range	Frequency	Samples Impacted	EPA-454/ R-99-005 Feb 2000	EPA Regulation & Guidance	ADEC AM&QA QAPP
RH/Dew Point	Hourly Recorded Relative Humidity	Dew Point Temp ≤Ambient Temp for time period, Dew Point Temp < 5°C change from previous hour, Dew Point Temp ≥ 0.5°C from previous hour, and Dew Point Temp < Ambient Temp for 12 consecutive hrs.	1/week or more frequent	G	Ch 8, Table		
Solar Radiation	Hourly Recorded Solar Radiation	Night time SR = 0, Day time SR < max SR for date and latitude	1/week or more frequent	G	Ch 8, Table		
Barometric Pressure	Hourly Recorded Barometric Pressure	BP < 1050 mb (sea level), BP > 945 mb (sea level), or Per site specific climatology criteria	1/week or more frequent	G	Ch 8, Table		
Precipitation	Hourly Recorded Precipitation	Note: Develop site specific climatology criteria for each season	1/week or more frequent	G	Ch 8, Table		
	Maintenance						
WS/VWS	Sensor bearings	Replace	1/6 months	G			
WD/VWD	Sensor Bearings	Replace	1/6 months	G			
SR		Per manufacturer's recommendations	Per manufacturer's recommendations	G			
DAS	Data Acquisition System (internal battery back-up)	Check Battery Back-up, Replace as needed	1/6 months	G			
	Bias/Accuracy						
WS, VWS	**Performance Audit**	5 points including zero, 2 m/s and 3 additional evenly spaced upscale points covering expected wind speeds for the site Audit points ≤± **(2 m/s + 5% of observed)** WS bearing torque threshold ≤ **PSD quality sensor Manufacturer's specs**		G	Ch 5	QA Handbook Vol IV Sec 2.7	Sec 7 MQO Table A8

OPERATIONAL EVALUATIONS TABLE - METEOROLOGICAL MEASUREMENT

S - single instrument hourly value, G - group of hourly values from 1 instrument

Parameter	Criteria	Acceptance Range	Frequency	Samples Impacted	EPA-454/ R-99-005 Feb 2000	EPA Regulation & Guidance	ADEC AM&QA QAPP
WS/WD (Sonic Anemometer)	Performance Audit	Collocated for minimum 72 hrs with on-site calibrated cup/vane or aerovane anemometer CTS **WS criteria** • ≤ ± 0.2 m/s + 5% observed CTS • SD of differences ≤ ± 0.2 m/s • Qualifications WS > 1 m/s **WD criteria** • ≤ ± 5° observed CTS • SD of differences ≤ ± 2° • Qualifications WS > 1 m/s	**NCore/SLAMS** 1/year **SPM** 1/yr (suggested) **PSD** Every sensor within 30 days of start-up and 1/6 months thereafter			QA Handbook Vol IV Sec 2.7.3.2 CTS Method	
WD, VWD	Performance Audit	Alignment to True North + linearity audit points at: 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°, 360° Alignment ≤ ± 5° Linearity (All Points) ≤ ± **3° (included in ≤ ± 5° above)** WD bearing torque threshold ≤ **PSD quality sensor manufacturer's specs**		G	Ch 5 Ch 8	QA Handbook Vol IV Sec 2.7	MQO Table, Table A8 Sec 16
Vector Data/DAS (WS, WD, σΘ, σw)	Performance Audit	WS ≤ ± **0.2 m/s** WD ≤ ± **5°**		G		QA Handbook Vol IV Sec 2.8	
Temp	Performance Audit	Minimum 3 point audit representative of min avg low to max avg high temps for the location. (e.g., -30°C, 0°C, +30°C) Each point ≤ **±0.5°C of NIST Traceable Standard**		G	Ch 5 Ch 8	QA Handbook Vol IV Sec 3.6	MQO Table, Table A8 Sec 16

OPERATIONAL EVALUATIONS TABLE - METEOROLOGICAL MEASUREMENT

S - single instrument hourly value, G - group of hourly values from 1 instrument

Parameter	Criteria	Acceptance Range	Frequency	Samples Impacted	EPA-454/ R-99-005 Feb 2000	EPA Regulation & Guidance	ADEC AM&QA QAPP
ΔT	**Performance Audit**	Side-by-side audit of 10m and 2m temp probes with a minimum 3 point audit representative of min avg low to max avg high temps for the location. (e.g., -30°C, 0°C, +30°C) Each point ≤ **±0.5°C** of NIST Traceable Standard and 10m sensor ≤ **±0.1°C** of 2 m sensor at all points		G	Ch 5 Ch 8	QA Handbook Vol IV Sec 3.6	MQO Table, Table A8 Sec16
RH/Dew point	**Performance Audit**	1-point audit of RH/DP sensor agaist NIST Traceable RH Standard (±2% RH accuracy) RH sensor ≤ **± 7% of RH Standard**		G	Ch 5 Ch 8	QA Handbook Vol IV Sec 5	MQO Table, Table A8 Sec 16
Solar Radiation (SR)	**Performance Audit**	1-point audit against in-cert. First Class Pyranometer SR sensor ≤ **± 5% of First Class Pyranometer**		G	Ch 5 Ch 8	QA Handbook Vol IV Sec 6	MQO Table, Table A8 Sec 16
Barometric Pressure (BP)	**Performance Audit**	1-point audit against pressure standard of known quality (see pressure std. min. requirements) BP sensor ≤ **± 3 mb (0.3 kPa)**		G	Ch 5 Ch 8	QA Handbook Vol IV Sec 7	MQO Table, Table A8 Sec 16
Precipitation	**Performance Audit**	Minimum 3 point audit Each point ≤ **± 10% of measured H_2O input,** or **≤ ± 5 mm H_2O**		G	Ch 5 Ch 8	QA Handbook Vol IV Sec 4	MQO Table, Table A8 Sec 16

ADEC – Alaska Department of Environmental Conservation
AM&QA QAPP – Air Monitoring and Quality Assurance QAPP (used by the USEPA to develop the MQO tables for meteorological measurements for Vol. IV guidance document)

SYSTEMATIC ISSUES TABLE - METEOROLOGICAL MEASUREMENT METHODS S - single instrument hourly value, G - group of hourly values from 1 instrument							
Parameter	**Criteria**	**Acceptable Range**	**Frequency**	**Samples Impacted**	**EPA-454/ R-99-005 Feb 2000**	**EPA QA Handbook Volume IV**	**ADEC AM&QA QAPP**
	Data Completeness						
All Met Parameters		≥ 75% NCore, SLAMS, SPM ≥ 90%, Windblown Dust OTM	Quarterly Monthly	G			
	QC Checks						
	DAS Clock/timer Verification	≤ ± 1 minute.	Each site visit weeks	G			
	Bias/Accuracy						
All Met parameters	Technical Systems Audit	NCore/SLAMS/SPM networks	1/3 years.	G		QA Handbook Vol IV Sec 10 & App. A	
		PSD, Windblown Dust OTM	Within 1 month of start-up and semi-annually thereafter	G			

ADEC – Alaska Department of Environmental Conservation
AM&QA QAPP – Air Monitoring and Quality Assurance QAPP (used by the USEPA to develop the MQO tables for meteorological measurements for Vol. IV guidance document)

Appendix C
Sand Motion Measurement Quality Objectives Validation Template

MQOs for sand motion monitoring conducted for this method should follow the guidance in the 2008 Owens Valley PM10 Planning Area State Implementation Plan (2008 OVPA SIP, Chapter 8 Attachment C).

CRITICAL CRITERIA TABLE - SAND MOTION MEASUREMENT METHODS

Parameter	Criteria	Acceptable Range						Samples Impacted	Guidance 2008 OVPA SIP
	Method	**Measurement Method Characteristics**							
		Reporting Units	**Range**	**Sensitivity**	**Resolution**	**Sampling Frequency**	**Raw Data Collection Frequency**		
Sensit	Particle Count Average (PC)	PC	2.00E+20	1x, 10x		2-sec.	5-min.	All Data	SIP Ch. 8, Att. C
		PC	2.00E+20	1x, 10x		2-sec.	hourly	All Data	SIP Ch. 8, Att. C
	Kinetic Energy (KE)	KE	1.00E+05	1x, 10x		2-sec.	5-min.	All Data	SIP Ch. 8, Att. C
		KE	1.00E+05	1x, 10x		2-sec.	hourly	All Data	SIP Ch. 8, Att. C
	Height to center of sensor	cm	15±1cm	0.1 cm	0.1 cm	every site visit	every site visit	All Data	SIP Ch. 8, Att. C
	Data logger clock time	minutes	NA	1 second	1 second	2-sec.	every site visit	All Data	SIP Ch. 8, Att. C
	Sampling Period	minutes	NA	1 second	1 second	5±1 min.	every site visit	All Data	SIP Ch. 8, Att. C
Cox Sand Catcher	Mass	grams	5 kg	0.1 grams	0.01 grams	monthly	per wind event	All Data	SIP Ch. 8, Att. C
	Height to center of inlet	cm	15±1cm	0.1 cm	0.1 cm	every site visit	every site visit	All Data	SIP Ch. 8, Att. C
Field Balance	Mass	grams	5 kg	1 gram	1 gram	every site visit	every site visit	All Data	SIP Ch. 8, Att. C
	Mass Calibration	grams	5 kg	1 gram	1 gram	beginning and end of each mass processing day	beginning and end of each mass processing day	All Data	SIP Ch. 8, Att. C
	Mass Calibration Check	grams	150 gms	1 gram	1 gram	every site visit	every site visit	All Data	SIP Ch. 8, Att. C
Lab Balance	Mass	grams	5 kg	0.1 gms	0.01 gms	every mass processing day	every mass processing day	All Data	SIP Ch. 8, Att. C
	Re-weigh 10% of all sand catch samples	grams	5kg	0.1gms	0.01 gms	every mass processing day	every mass processing day	All Data	SIP Ch. 8, Att. C
	Mass Calibration, Min. 3 points + zero over range of expected sample masses	grams	5kg	0.1 gms	0.01 gms	beginning and end of each mass processing day	beginning and end of each mass processing day	All Data	SIP Ch. 8, Att. C

OPERATIONAL EVALUATIONS TABLE - SAND MOTION MEASUREMENT METHODS

Parameter	Criteria	Acceptance Range	Frequency	Samples Impacted	Guidance 2008 OVPA SIP
Sensit PC	Response Verification	Any response acceptable	Every site visit	All sites	SIP Ch. 8, Att. C
Sensit KE	Response Verification	Any response acceptable	Every site visit	All sites	SIP Ch. 8, Att. C
	KE Background	Background response must be consistent to use KE to calculate ratios to sand catch	Every Sensit	All sites	SIP Ch. 8, Att. C
Sensit PC, KE	Sampling interval	All intervals accounted for	Every sample	All Samples	SIP Ch. 8, Att. C
	Elevated Sensit Response	Total output for day coincide with upscale wind events	Daily	All sites	SIP Ch. 8, Att. C
	Sensit Response	Relationship between KE, PC should be linear, if not, PC saturation may have occurred	Daily	All sites	SIP Ch. 8, Att. C
	Deviation	Deviations >10x the PC or KE to sand catch ratio, Investigate/Flag	Every sample	All Samples	SIP Ch. 8, Att. C
	Zero Response	Response > 0 at low (<5m/s) or no wind speed, investigate	Every sample	All Samples	SIP Ch. 8, Att. C
	Sensit Response	Response > 0 at temperatures <0°C and low (<5m/s) or no wind speed, investigate	Every sample	All Samples	SIP Ch. 8, Att. C
	Duplicate Interval Data	Investigate all duplicate interval data for logger malfunction	Every sample	All Samples	SIP Ch. 8, Att. C
Sand Catch	Wet Sample Mass	Wet Samples weighed, then dried @ ≤80°C, then weighed again for data of record	All Wet Samples	All Wet Samples	SIP Ch. 8, Att. C

SYSTEMATIC CRITERIA TABLE - - SAND MOTION MEASUREMENT METHODS

Criteria	Frequency	Acceptable Range	Frequency	Samples Impacted	Guidance 2008 OVPA SIP
Sensit Data Completeness	Monthly	All monitoring intervals must be accounted for	Weekly	All Data	SIP Ch. 8, Att. C
Sand Catcher Data Completeness	Monthly	Every Sensit must have an associated sand catcher	Monthly	All Data	SIP Ch. 8, Att. C

2008 OVPA SIP – 2008 Owens Valley PM_{10} Planning Area Demonstration of Attainment State Implementation Plan [4]

Appendix D
CSC and Sensit Field Documentation Form

CSC Field Form.xls

Technician: Date (mm/dd/yyyy): / /

Site #	Time PST	Pre-Sensit Height, cm	Sensit Response	Final Sensit Height, cm	Pre-CSC Inlet Height, cm	Field Cal Weight, kg	CSC Full, kg	CSC Tare, kg	Final CSC Height, cm	No VP
	:					.	.	.		
	:					.	.	.		
	:					.	.	.		
	:					.	.	.		
	:					.	.	.		
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	:					.	.	.		

Marble Rankings: 0=No Crust 1=Complete Damage 2=Indent or Surface Damage 3=No Damage 4=Wet

Site #	Rank	Surface Description	Comments and Maintenance

Delivered By:	Date:
Received By:	Date: